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HAND DELIVERED
AUG 1 2003
03.02677
Utah Division of Solid and Hazardous Waste

August 1, 2003

Mr. Carl Wadsworth
Utah Department of Environmental Quality
Division of Solid and Hazardous Waste

Salt Lake City, Utah 84114

Subject: Class I Municipal Solid Waste Landfill Renewal
Three Mile Canyon Landfill
Summit County, Utah

Dear Mr. Wadsworth:

The following document is the Class I Municipal Solid Waste Landfill Renewal for the Three Mile Canyon Landfill located in Summit County.

Our services consist of professional opinions and recommendations made in accordance with generally accepted geotechnical and environmental engineering principles and practices. This warranty is in lieu of all other warranties either expressed or implied.

Should you have any questions, please do not hesitate to call us at (801) 412-0003.

Sincerely,

ATC Associates Inc.

Dean Henderson
Staff Geologist

Bryce J. Taggart
Operations Manager

DH/BT

cc: (1) Addressee
(1) Mr. Mark Offret, Summit County Public Works Department

CLASS I & IV MUNICIPAL SOLID WASTE LANDFILL RENEWAL
THREE MILE CANYON LANDFILL
SUMMIT COUNTY, UTAH

August 1, 2003

Prepared for:

Summit County
P.O. Box 1280
Coalville, Utah 84017

Prepared by:

ATC Associates Inc.
2681 East Parleys Way, Suite 106
Salt Lake City, Utah 84109

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CLASS I & IV MUNICIPAL SOLID WASTE LANDFILL RENEWAL
THREE MILE CANYON LANDFILL
SUMMIT COUNTY, UTAH

1. GENERAL DATA

The Three Mile Canyon landfill became operational in 1986, and has been operated continuously since then by County personnel. The landfill has been operated in accordance with the original design and plan of operations prepared by Forsgren-Perkins Engineering, p.a. A Class I & IV Solid Waste Permit Renewal is now required by the Utah Department of Environmental Quality, Division of Solid and Hazardous Waste (UDSHW). The landfill is the only facility for municipal waste within Summit County. A Class IV Landfill is currently being operated near Henefer.

1.1 NAME OF FACILITY

Three Mile Canyon Landfill

1.2 SITE LOCATION

Within the southern half of Section 5, Township 1 South, Range 5 East, Salt Lake Base and Meridian, about four miles south of Wanship and a half mile southwest of Rockport Reservoir. The site is located on the north side of Three Mile Canyon. The latitude and longitude coordinates of the front gate are:

Latitude: 40°45'28"
Longitude: 111°24'00"

1.3 FACILITY OWNER

The property is owned by Summit County. A copy of the deed is included in Appendix A. The property surrounding the landfill is owned by Utelite Mining Company, as shown on Figure 1. The area is zoned as AG-100, agricultural.

1.4 FACILITY OPERATOR

Summit County

1.5 CONTACT PERSON

Kevin Callahan, Public Works Administrator
1755 South Hoytsville Road
Coalville, UT 84017
(435) 336-~~5552~~ 3978

1.6 TYPE OF FACILITY

Class I Municipal Solid Waste Landfill
Class IV Construction Demolition Debris Landfill

1.7 PROPERTY OWNERSHIP

Summit County

1.8 CERTIFICATION OF SUBMITTED INFORMATION

Kevin Callahan, Public Works Director
(Name of Official) (Title)

I certify under penalty of law that this document and all appendices were prepared under my direction and supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Signature: Kevin Callahan, Date July 29, 2003

SUBSCRIBED AND SWORN to before This day of July 29, 2003.

My commission expires on the 6th day of April, 2007.

Launa S. Blonquist
Notary Public in and for

(SEAL) Summit County, Utah.

Notary Public
LAUNA S. BLONQUIST
60 North Main
Coalville, Utah 84017
My Commission Expires
April 6, 2007
State of Utah

2. INTRODUCTION

Summit County (County) administers the collection and disposal of commercial and residential solid waste in Summit County. The Three Mile Canyon landfill is the only operating municipal Class I & IV landfill within Summit County. A Class IV landfill for construction and demolition debris is currently in operation near Henefer. Collection of residential and commercial waste is performed by BFI, a private vendor operating under contract with the county.

2.1 GENERAL DESCRIPTION OF FACILITY

The landfill is located in a relatively flat basin on the north side of Three Mile Canyon approximately one half mile southwest of Rockport Reservoir and approximately 4 miles south of Wanship (see Figure 1). The front gate is located at latitude 40° 45'28" and longitude 111°24'00". The landfill site occupies approximately 103 acres, which includes the permitted landfill cell, maintenance building, scale station, gatehouse, stormwater detention pond, and access roads. The currently permitted landfill cell currently occupies approximately 23.6 acres.

Drainage occurs within a natural channel, which flows southeast, where it joins the larger intermittent stream, which drains Three Mile Canyon. The current surface of the active cell is relatively flat, sloping gently to the northeast. The topography rises sharply to the west and north of the cell; the permit boundary is located on the surrounding hillside. A berm has been construction on the east and south sides of the cell. A drainage diversion has been constructed around the perimeter of the landfill to prevent surface drainage from entering the landfill. The surface drainage is routed into the natural drainage channel flowing to the south and eventually into the Three Mile Canyon intermittent stream.

A paved road accesses the site from the main canyon road located approximately one quarter mile south of the site. The entrance to the landfill is controlled at the scale area.

The landfill has been filled in stages, beginning with eastern one-third of the permit area (approximately 5.5 acres). After this area was filled with waste, the area immediately to the west was excavated, and the two areas (totaling 12 acres) have subsequently been filled with up to 70 feet of waste. The berm has been constructed in 10 to 20 foot raises along the north, south and east sides of the area. Waste is currently being placed west of the berm. As waste placement reaches the elevation of the berm, the cell area will be developed laterally to the west and vertically (see details in Figure 4).

The soils at the site consist of primarily alluvial and colluvial low permeability silty clay with thicknesses ranging from 5 to 20 feet. Bedrock underlying the soils consists of fine-grained low permeability siltstone. Groundwater below the site is moderately deep with groundwater levels in the monitor wells ranging from 36 to 65 feet below ground surface. Groundwater was detected in several exploratory borings at depths ranging from 19 to 25 feet, however this appears to be perched water.

A Solid Waste Management Plan (Management Plan) for Summit County was prepared by Bingham Environmental, Inc. (Bingham) in February 1994 and 1997. Since the Henefer Class I municipal landfill was scheduled for closure in 1994, the Three Mile Canyon landfill was an integral part of the Management Plan. After the Management Plan was written, the Class I portion of the Henefer landfill was subsequently closed, leaving only the Three Mile Canyon landfill to receive all of Summit County's Class I municipal solid waste. The waste disposed at the site includes residential and commercial municipal solid waste and commercial waste. The current Summit County population is estimated to be approximately 32,831 in 2003 based on 2000 Census Data and population increases estimated by the Utah Office of Planning and Budget. The population for the county is expected to increase to 43,464 by the year 2011. Based on this population projection, an additional 518,214 tons of solid waste will be disposed in this facility by that time (during the remaining 10-year time period projected in the 20-year plan). During the duration of the 5-year permit, 2003, through 2008, approximately 326,878 tons of solid waste are estimated to be disposed at the landfill. The calculations for the projected volume requirements of the landfill are presented in Appendix C.

There are residential developments north and west of the landfill, on top of the ridges surrounding the basin. To the east beyond the ridge is Rockport Reservoir. The Utelite mining plant is located southwest of the landfill site.

2.2 LEGAL DESCRIPTION OF FACILITY

The facility is located in the south half of Section 5, Township 1 South, Range 5 East. The description of the property boundary is:

> Beginning at a point which falls North 663.21 feet, West 1,779.79 feet from the Southeast corner of said Section 5, Township 1 South, Range 5 East, Salt Lake Base and Meridian said Section corner is a mound of stone on a North-South fence line; thence North 67°45'49" East 900.0 feet; thence North 12°48'28" West 827.0 feet; thence North 57°30'44" West 1,440.0 feet; thence South 79°30'16" West 2,148.5 feet; thence South 13°47'58" East 1,945.22 feet: thence North 75°06'51" East 2,028.5 feet to the point of BEGINNING.

3. PLAN OF OPERATION

The purpose of the Plan of Operation (Plan) is to provide a written description of the daily operation of the Summit County Three Mile Canyon Landfill (Landfill). The Landfill is a solid waste management facility for disposal of municipal, construction and demolition debris, and solid waste.

A landfill is a dynamic system, which undergoes regular development. Changes may occur in types and quantities of disposal materials, topography of the landfill, demographics of the surface area, or administrative or regulatory requirements. These changes will be reflected in the manner in which the landfill is operated to conserve landfill space and protect human health and the environment. The intent of this Plan is to provide an accurate description of the daily operations and procedures while allowing for modification, which may be required to compensate for operational changes.

3.1 SCHEDULE OF CONSTRUCTION

Construction began on the Landfill in 1986 following permit approval from the Utah Division of Solid and Hazardous Waste; therefore, a construction schedule has not been developed for this application and is not considered necessary.

3.2 OPERATIONAL PROCEDURES

The Landfill has one cell, which will continue to be used under the Permit Renewal for disposal of municipal, construction and demolition debris solid waste. The area of this cell has been extended to the boundaries established under the original permit to enable utilization of the cell as an existing landfill rather than as a lateral expansion.

3.2.1 Construction of Disposal Cell

The material excavated from the cell expansion has been stockpiled in areas west and south of the cell, as well as being used to create a diversion barrier to precipitation run-on. The working face of the landfill will be constructed and maintained with a maximum three horizontal to one vertical slope.

The waste will be unloaded at the base of the working face and will be spread over the working face by a track-mounted dozer or steel-wheeled compactor. All waste will compacted prior to placement of daily cover (minimum 6-inches). The daily cover material will consist of soil from the cell expansion. Unloading of waste will be restricted to one area of the working face to limit vehicular traffic and to limit the amount of waste exposed and requiring daily cover.

Intermediate cover may, at the discretion of the Landfill Manager, be placed over any completed portion of the cell.

Intermediate cover may, at the discretion of the Landfill Manager, be placed over any completed portion of the cell. Intermediate cover will consist of a minimum thickness of 12-inches of native soil and will be compacted with a minimum effort to facilitate traffic ability over the cell. In addition, a temporary 6-inch layer of gravel may be placed over the intermediate cover in the unloading areas and on the temporary access roads to improve traffic ability to the working face and provide year round access.

Once the cell is completed a final cover will be constructed with a minimum 3% grade and the surface will be revegetated. The final cover will consist of 18-inches of compacted clay available from the existing stockpiles of native soil, overlain by a 6-inch thick topsoil layer. The topsoil also will be available from the stockpiled materials.

3.2.2 Equipment

The Landfill will be operated with a minimum of two pieces of heavy equipment; a crawler-dozer and a compactor. These units are currently being utilized by Summit County Landfill personnel, and may be augmented as necessary with additional equipment, such as graders and loaders, from the Summit County Road Department. A scale for weighing waste loads is located near the entrance of the landfill. Summit County Landfill personnel will accurately account for load weights and volumes of each delivery vehicle arriving at the site.

The Landfill Manager will have a utility truck capable of moving around the site during inclement weather and powerful enough to pull small trailer-mounted equipment, which may be needed at the site. This vehicle will carry whatever tools are necessary for routine maintenance of the heavy equipment. Auxiliary equipment at the site may include a small potable water tank for wetting the roads or washing equipment.

3.3 ON-SITE SOLID WASTE HANDLING PROCEDURES

The Landfill is owned and operated by Summit County. The Summit County Public Works Administrator acts as Landfill Manager with supervisory responsibility over the Landfill and personnel. Daily operation of the Landfill is under the direction of the landfill operator, known as the Facility Supervisor.

The Facility Supervisor is responsible for unlocking the gate at the beginning of each day and for directing the collection vehicles to the proper location for disposal of waste. Direction of vehicles also may be accomplished though the placement of directional signs. The Landfill will be attended by at least two operators at all times that the Landfill is open.

The County installed a scale for weighing waste loads at the landfill. The facility supervisor will accurately account for load weights and volumes of each delivery vehicle arriving at the site.

An area near the working face will be designed as a collection area for tires, paints, batteries, used oil and the white goods. This collection area will be established for white goods, paints, batteries, used oil and tires, which may be discovered in waste unloaded by the commercial hauler who transports municipal solid waste to the Landfill.

Summit County intends to contract with steel reclamation and recycling firms to remove white goods and batteries from the landfill on a periodic basis. The contactor will be required to meet all State of Utah and EPA requirements for removal of chlorofluorocarbons from white goods. Used oil will be collected by the landfill and burned as fuel to heat the landfill maintenance building. Tires will not be accepted in bulk at the Landfill; however, if local waste tire generators and/or a waste tire disposal company wish to utilize Landfill property for collection of tires prior to disposal, the County will assist in providing a waste tire collection area. Otherwise, the Landfill will only collect waste tires that arrive at the landfill in waste unloaded by commercial haulers. The tire collection area will be maintained in a manner that protects human health and environment by a) maintaining the piles in a manageable size to reduce the chance of an accidental fire from spreading between piles, and b) periodic monitoring of the entire area for mosquito protection and, if found, treatment or removal of tires. Green waste will be collected near the area of he working face. Periodically the green waste will be chipped and disposed at the landfill.

Incoming waste will be deposited at the working face under the direction of the Facility Supervisor. Refuse will be spread in thing layers approximately one foot thick across the working face, and then will be compacted by six passes with either the crawler or compactor. At the end of the working day, the operator will spread a minimum of six inches of daily cover material over the compacted refuse.

3.4 SCHEDULE FOR CONDUCTING INSPECTIONS AND MONITORING

The schedule for inspections and monitoring of landfill facilities to ensure proper operation and maintenance is provided in Table 1.

TABLE 1
INSPECTION AND MONITORING SCHEDULE

Inspection/Monitoring Activity	Frequency
Access road condition and maintenance	During operation as needed
Fence inspection and maintenance	Quarterly
Daily cover inspection	During daily operation
Post closure final cover inspection	Quarterly
Drainage channel condition	Quarterly
Landfill equipment maintenance	Per manufacturers recommendations

3.5 CORRECTIVE ACTION PROGRAM FOR CONTAMINATED GROUNDWATER

The Landfill has two downgradient groundwater monitor wells (MW3 and MW7) and one upgradient well (MW-9) west of the disposal cell as identified in Figure 2. Completed detection monitoring in May 2003 and is now undergoing Assessment monitoring to evaluate potential impacts to the groundwater from the landfill operation. Results of Assessment Monitoring and subsequent statistical analysis of groundwater data may or may not require corrective action.

3.6 CONTINGENCY PLANS

This Contingency Plan is designed to minimize hazards to human health or the environment from any unplanned sudden or non-sudden discharge to air, soil, surface or groundwater. The provisions of this plan shall be carried out immediately when there is an emergency situation or release, which could threaten human health or the environment. Emergency evacuation of the site will not be necessary given the nature of the waste materials stored and processed at the site. The probability of fire, explosion, or toxic vapor generation from any emergency incident is remote.

3.6.1 Fire or Explosion

A landfill fire or explosion would be particularly hazardous in the presence of discarded household chemicals, paints, fuels, etc.; however, waste load monitoring is expected to effectively eliminate this potential. A fire may be started by spontaneous combustion in refuse containers, but is usually the result of vandalism or disposal of hot coals and ashes. Daily cover effectively prevents fires from spreading throughout the landfill.

The primary means of fire control will be the exclusion and or isolation of hot or burning loads. In the event that fires do erupt during operation hours, the burning material will be separated from other material and covered with soil, using onsite earthmoving equipment. This action will be supported, when necessary, by the availability of additional equipment owned by the Summit County Highway Department.

Small fires may be extinguished with fire extinguishers provided in the site vehicles or by using a water tank, if available. Upon notification of an fire or explosion, which is not controllable with onsite fire protection equipment, a long blast (greater than 30 seconds) on a vehicle horn will be sounded, nonessential equipment will be shut down, and all site personnel will assemble outside the landfill entrance. The local Summit County Fire Department will be alerted and all personnel will move to a safe distance from the involved area until the fire is extinguished. Secondary fire control may also be provided by other Summit County Fire Department units. The telephone number and location of the nearest fire station will be displayed in a conspicuous place in the area of the working face and in the site office. The Landfill employees will participate in a fire drill conducted on an annual basis.

Fires which occur during times that the landfill is closed are more difficult to control due to the time available for the fire spread. If a fire is reported after hours, the Landfill Manager may utilize site equipment to segregate the burning portion and bury the fire with soil. Otherwise, the local fire department will be summoned to control the fire.

3.6.2 Explosive Gas Release

Due to the size, remote location and semi-arid nature of the site, a significant amount of explosive landfill gas is neither expected to be generated nor to migrate offsite. The Landfill Manager is responsible for quarterly monitoring of landfill gas using a methane detection meter capable of measuring methane at levels below the Lower Explosive Limit (LEL). Gas monitoring will be conducted to test for methane at the LEL at the facility boundary and at 25% of the LEL in the facility structures. In the event that explosive gases are detected above the LEL during monitoring, or at any other time, the emergency audible alarm and evacuation procedures outlines in Section 3.6.1 will be implemented.

Summit County will conduct quarterly monitoring for explosive gas at Three Mile Canyon at the locations indicated on the attached engineering drawing. A sample of the form 'Landfill Gas Monitoring' is included in Attachment 2 of the Groundwater Monitoring Plan provided in Appendix B. Completed Forms are to be kept on file at the site for inclusion in the annual report.

3.6.3 Failure of Containment System

There are no containment systems at the site other than a storm water collection area. No leachate collection structures exist or are planned for the site, and no containment system will be located at the site.

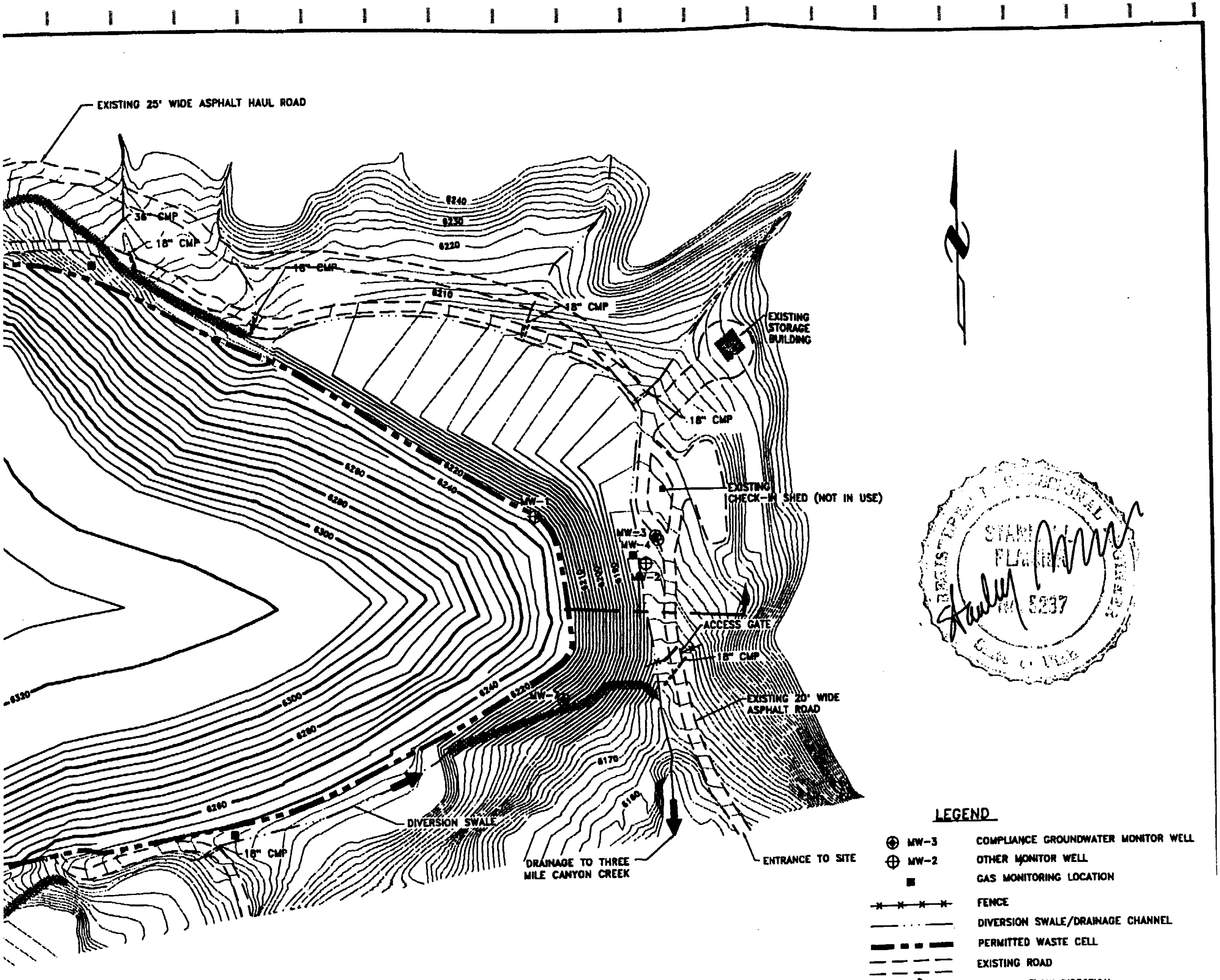
3.7 ALTERNATIVE WASTE HANDLING OR DISPOSAL PLAN

The landfill will have a minimum of one crawler and one compactor. In the event that one unit of equipment cannot operate due to maintenance or repair, the other unit will be utilized to push refuse to the working face and to place cover material, if possible. No contingency is planned for additional compaction equipment.

The landfill cell comprises a total of 23.6 acres, and is large enough that if a portion of the site must be closed due to emergency, or becomes inaccessible; it is likely that another area could be designated to receive waste materials on a temporary basis. If on-site roads become impassible, the Landfill Manager may elect to temporarily close the Site.

3.8 MAINTENANCE OF INSTALLED MONITORING EQUIPMENT

Three groundwater wells are presently being monitored at the site. Assessment monitoring of these wells is now required (UAC R315-308-2(11)(a)) and the wells are monitored on a quarterly basis. When assessment monitoring is no longer necessary these wells will be monitored on a semi-annual basis for the life of the Landfill and during any post-closure care period. Inspection and maintenance procedures for the monitor wells will consist of a visual inspection performed during semi-annual sampling and will include examination of the concrete pad for cracks, shifting or other damage. If damage to the well casing is discovered, these sections will be repaired or the well will be replaced as may be necessary and practical. Details of the inspection and maintenance activities will be recorded in a field notebook and copies will be kept of file at the Site.


EXISTING 25' WIDE ASPHALT HAUL ROAD
36" CMP
18" CMP
18" CMP
18" CMP
18" CMP
18" CMP
18" CMP
6240
6230
6220
6210
EXISTING STORAGE BUILDING
EXISTING CHECK-IN SHED (NOT IN USE)
MW-1
MW-3
MW-4
MW-2
MW-5
ACCESS GATE
EXISTING 20' WIDE ASPHALT ROAD
6320
6300
6280
6260
6170
6160
DIVERSION SWALE
DRAINAGE TO THREE MILE CANYON CREEK
ENTRANCE TO SITE
LEGEND
MW-3 COMPLIANCE GROUNDWATER MONITOR WELL
MW-2 OTHER MONITOR WELL
GAS MONITORING LOCATION
FENCE
DIVERSION SWALE/DRAINAGE CHANNEL
PERMITTED WASTE CELL
EXISTING ROAD

3.9 PROCEDURES FOR CONTROLLING DISEASE VECTORS

The primary technique for controlling disease vectors in and around the Landfill area is the addition of daily cover (minimum six inches). Exclusion of specific types of solid wastes will be necessary to control disease vectors and the subsequent spread of disease. As a general rule special wastes such as infectious waste, liquid wastes and tires, which may directly carry disease or lead to the propagation of disease vectors, will be excluded for the Landfill (see Section 3.10). However, because health facilities that generate less than 200 pounds of infectious waste per month and household generated infectious waste are not regulated, landfill employees will receive training to help recognize and avoid contact with infectious waste. Dead animals may be received at the Landfill. At the time the carcass is delivered for disposal a special cell is excavated and the carcass is immediately buried and covered with a minimum of 6 inches of cover.

3.10 PROCEDURES FOR EXCLUDING THE RECEIPT OF HAZARDOUS WASTE

The Landfill specifically excludes the following types of waste:

- Hazardous waste
- PCB containing waste
- Liquid waste (including septic and sump wastes)
- Toxic waste and chemical wastes
- Bulk loads of tires

The program to exclude the disposal of hazardous or PCB Containing waste shall conform to UAC Subsection R315-303-5 (7). The Facility Supervisor is responsible for identification and prohibition of excluded wastes. All employees will be trained in methods and techniques for identifying hazardous waste or waste containing PCB's, spotting liquid waste, drums, waste in sealed containers, Red-Bag waste, and waste which may exhibits unusual odors of markings. The Facility Supervisor at a minimum of once per day shall perform random inspections of waste loads at the face. The inspection results shall be included on the Load Inspection Record Form. If hazardous or PCB-containing waste is discovered on the working face it will be segregated from the other waste pending alternative disposal, and the Executive Secretary, the hauler, and generator shall be notified within 24 hours. The area containing the waste shall be restricted to other waste haulers pending removal of the material. The Landfill Manager will have the ultimate authority and responsibility for decisions regarding acceptance of rejection of any waste.

3.11 GENERAL TRAINING AND SAFETY PLAN

Each employee who works with solid waste at the Landfill will be trained and have a working knowledge of basic maintenance and operational techniques necessary to operate and maintain the facility in a manner which does not endanger human health and safety or environmental quality. Training will be accomplished through on-the-job training (OJT) and classroom training sessions.

The Landfill Manager, or a designated professional trainer will direct the training program. Initial training will be completed within three months of employment followed by an annual review of basic waste management skills.

TRAINING SCHEDULE

A. Introductory Training (half hour minimum): Synopsis of solid waste regulations, record keeping and transporter requirements.

Requirement:	All Personnel
Method:	OJT
Review:	Annual

B. Policies and Procedures (half hour minimum): Security, inspections and emergency response.

Requirement:	All Personnel
Method:	OJT, lecture/video course
Review:	Annual

C. Safety (one hour minimum): Personal protection, hazardous waste recognition, hazardous material handling, emergency response and first aid.

Requirement:	All Personnel
Method:	Lecture/video course
Review:	Annual

D. Landfill Operations: All landfill personnel will be enrolled annually in one of two courses offered by the Utah chapter of the Solid Waste Association of North America (SWANA). The courses include the Landfill Operator Course and the Waste Screening Course.

Requirement:	All Personnel
Method:	Classroom
Review:	Annual

Training documents will be kept with this Plan of Operation for five years.

3.12 OPERATING FORMS

The following forms (examples are included in Attachment 2 to the Groundwater Monitoring Plan provided Appendix B) shall be utilized as required and kept on file at the landfill:

- Daily Operating Record
- Load Inspection Record
- Quarterly Inspection Record
- Gas Monitoring Form
- Groundwater Monitoring Form

A Daily Operating Record form shall be completed during each day of operation at the landfill. Information shall include accurate load counts, type of waste received, load inspection log, and any deviation from the approved plan of operation, along with the reason for the deviation. Completed forms shall be kept on file at the site.

A Load Inspection Record shall be completed each time a load is inspected for the purpose of excluding hazardous waste (a minimum of once per day). The form is to be signed by the operator performing the inspection.

The landfill shall be inspected quarterly by landfill personnel. Observations shall be made to prevent malfunctions and deterioration, operator errors, or discharges which may cause or lead to the release of wastes to the environment or to a threat to human health. A sample form to be completed during each inspection is included in Appendix B. Completed forms shall be kept on file at the site.

During quarterly gas monitoring and quarterly groundwater monitoring, the appropriate forms shall be filled out and maintained on file at the site.

3.13 DUST CONTROL

The fugitive dust program is intended to control dust emissions from construction activities that will take place at the landfill, such as construction of the berm and the final cover. While the landfill is operational the fugitive dust emissions will be insignificant. The major potential source of fugitive dust during operations is vehicular traffic on the landfill's access road; minor amounts may be generated from placement of waste and daily cover. The access road will be paved from the site ingress to the point where the road enters the landfill cell, effectively eliminating the main source of dust during operations.

Dust control measures shall be implemented during the excavation, transport, and placement of all soils. During construction of the final cover, the Contactor shall provide a water truck for the application of water for dust control. Dry soils shall be wetted prior to construction activities each day if dust is being produced during these activities. Water shall be applied during the workday as necessary to minimize fugitive dust.

3.14 LITTER CONTROL

This section addresses the control of litter that may blow from the active face of the landfill. The preferred method of litter containment is operational controls, which have been previously addressed, namely the compaction of waste and the application of daily cover. In addition to these operational controls, a litter fence shall be constructed in order to reduce the chance for waste to blow off site.

An 8-foot high chain link fence shall be constructed to control blowing litter. Because the predominant winds are out of the west, the fence shall be installed along the eastern boundary of the disposal cell. Litter shall be periodically removed from the fence.

Litter, which has escaped from the landfill cell, shall be collected at least monthly. Litter collection shall also be performed after each strong wind event .

4. FINANCIAL ASSURANCE PLAN

Summit County has determined that they can demonstrate financial assurance for the closure and post-closure requirements using the *"local government financial test"*. Summit County will place a reference to the closure and post-closure care cost assured through the financial test into their next comprehensive annual financial report and every subsequent annual report until post-closure has been completed. The County will submit the required financial documentation to the Executive Secretary of the Solid and Hazardous Waste Board at the close of each fiscal year to demonstrate financial assurance.

An estimate for the closure and the post-closure maintenance and monitoring of the Three Mile Canyon landfill has been prepared, and is summarized in Table 2. The estimate is based on the total area for final closure of 24 acres for placement of clay, topsoil, and re-vegetation (estimated from Figure 4 of the Engineering Plans).

TABLE 2
SUMMARY OF ESTIMATED CLOSURE AND POST-CLOSURE COST

TASK	QUANTITY	UNITS	UNIT COST	TASK COST
Closure				
Conduct Site Evaluation	1	Lump Sum	$2,750.00	$2,750.00
Remove Building & Equipment	2	Lump Sum	$2,450.00	$4,900.00
Construction Storm Water	1	Lump Sum	$4,000.00	$4,000.00
Move & Place Clay	58,000	Cubic Yards	$3.20	$185,600.00
Soil Testing	58,000	Cubic Yards	$0.86	$49,880.00
Move & Place Topsoil	19,500	Cubic Yards	$1.50	$29,250.00
Final Grading	24	ACRES	$1,122.00	$26,928.00
Storm Water Controls	1	Lump Sum	$5,000.00	$5,000.00
Seeding – Re-vegetation	24	ACRES	$400.00	$9,600.00
			SUBTOTAL	**$317,908**
			10% ADMINISTRATIOVE SERVICES	$31,791
			12% TECHNICAL AND PROFESSIONAL SERVICE	$38,149
			10% CONTINGENCY	$31,791
			TOTAL CLOSURE	**$419,639**
Post Closure				
Site Inspections[1]	120	Events	$500.00	$60,000
Annual Maintenance[1]	30	Events	$1,500.00	$45,000
Gas Monitoring[2]	60	Lump Sum	$500.00	$30,000
Groundwater Monitoring/Report[2]	60	Lump Sum	$2,000.00	$120,000
Groundwater Analysis[2]	60	Lump Sum	$2,000.00	$120,000
Repair and Maintain Cover[3]	1440	Cubic Yards	$12.00	$17,280
Abandoned Wells[4]	289	Feet	$17.75	$5,130
			SUBTOTAL	**$397,410**
			6% ADMINISTRATIVE SERVICES	$23,845
			7% TECHNICAL AND PROFESSIONAL SERVICES	$27,819
			10% CONTINGENCY	$39,741
			TOTAL POST CLOSURE	**$488,815**
			TOTAL	**$908,454**

NOTES TO TABLE

[1] May be reduced to annual inspections upon site stabilization, with DEQ.
[2] May be discontinued upon site stabilization, with DEQ approval.
[3] Calculated at 2 cubic yards/acre x 24 acres x 30 years.
[4] Calculated at 289 feet (total well depths of MW3, MW7 & MW9) x $17.75/foot.

No Frost Protect

5. CLOSURE AND POST-CLOSURE PLANS

5.1 GENERAL

Final closure activities will be implemented when the capacity of the landfill has been reached. Closure of the site is to be performed in such a manner as to minimize the need for post-closure maintenance and minimize the potential effects of the landfill on the surrounding environment. Post-closure operations will consist of groundwater monitoring and periodic site inspections to determine that the site is performing as designed.

5.1.1 Final Cover and Grading

The final cover of the Three Mile Canyon Landfill will be constructed to meet the requirements of a standard design, as specified in UAC 315-303-3(4)(a) and will be the basis for financial assurance cost estimates for closure of the landfill .However, the County may propose alternative cover designs at the time of closure that would meet the performance standards of this section.

5.1.2 Volume Capacity

The total remaining volume capacity of the landfill is approximately 1,036,400 cubic yards (yd^3). At an average disposal rate of 100 tons per day of waste and an average placed waste density of 1000 pounds per yd^3, the volume of the landfill is expected to meet the estimated requirements of Summit County for the 20-year period identified in the Management Plan.

5.1.3 Closure Schedule

Closure activities at the landfill will commence within 30 days after placement of waste and shall be completed within 180 days.

5.1.4 Cost Estimate

The engineering cost estimate for the closure of the Three Mile Canyon Landfill is $419,639. The detailed cost estimate is provided in Table 2.

5.1.5 Final Inspection

A final inspection will be performed at the Three Mile Canyon site at the termination of the landfill activities. The final inspection will determine if the landfill meets the closure requirements as outlined in the permit and closure plans. Inspection will include: cell cover design requirements, run-on and run-off controls, and maintenance of proper final grade on the cell to promote run-off.

5.2 MONITORING

In addition to the periodic inspections, post closure monitoring of the landfill will include sampling the groundwater monitor wells at the site. The wells will be sampled on a semi-annual basis through both the active period of the landfill operations and the post-closure period.

Methane gas will also be monitored quarterly during the post-closure period at the perimeter of the landfill and within any buildings at the landfill site. If sufficient data indicates that little or no gas is generated, application will be made to the Executive Secretary to modify the schedule for gas monitoring, or to discontinue monitoring.

Any required maintenance of the monitoring structures will be addressed during scheduled inspections.

5.3 MAINTENANCE

Post-closure maintenance will consist of inspecting the cover and run-on / run-off control structures and making and necessary repairs. Possible maintenance activities may include grading, repair of swales and riprap areas, and repair or replacement of culverts. Inspection and maintenance at the landfill will be performed semi-annually during the post closure period and shall coincide with the scheduled monitoring events.

5.4 POST-CLOSURE CARE COST ESTIMATES

The estimated cost of post-closure monitoring and maintenance is $488,815. A summary of the estimated cost is included in Table 2.

6. GEOHYDROLOGICAL ASSESSMENT

6.1 REGIONAL GEOLOGY

The site is located in the Middle Rocky Mountain physiographic province, between the Wyoming Basin to the east and the Basin and Range province to the west. The Middle Rocky Mountain province in Utah includes the north-south trending Wasatch Range and the east-west trending Uinta Mountains.

The site is located within the Weber River drainage. The Weber River flows to the north-northwest, eventually emptying into the Great Salt Lake near Ogden. The Wanship Dam, located approximately 2 miles from the site, backs up the Weber River to form Rockport Reservoir.

Bedrock in the vicinity of the site consists generally of three main formations: the Frontier Formation (Upper Cretaceous), the Kelvin Formation (Lower Cretaceous), and the Preuss Sandstone (Middle Jurassic). These formations all consist of sandstone, shale, and siltstone (see Figure 2).

6.2 LOCAL GEOLOGY

The site is located within a topographic basin, which opens to the south into Three Mile Canyon. Elevations within the site boundary range from 6180 to 6570 feet above sea level. The central portion of the property where the permitted cell is located is relatively flat. Surrounding the flat area to the west, north, and east are steep hillsides with slopes of 40 to 50 percent.

The flat portion of the site is underlain by 10 to 20 feet of colluvial reddish-brown clays and silty clays. The steeper slopes are underlain by 5 to 10 feet of sandy silty clay. The bedrock underlying the site is the Preuss Sandstone formation, which locally consists of reddish-brown siltstone. The siltstone is moderately hard and closely to moderately fractured in the upper 10 to 15 feet, but becomes tighter with depth. The Rock Quality Designation (RQD), defined as the percentage of core per foot that is longer than 4 inches, averages about 50 percent for the siltstone to a depth of 100 feet. The in-situ permeability of the bedrock ranged from 1.9×10^{-5} to 9.7×10^{-7} cm/sec.

There are no active faults in the vicinity of the landfill. Two thrust faults have been mapped in the area, the first approximately one mile north of the site, running parallel to Kent canyon, and the second approximately 120 feet south of the site. These faults are thought to have occurred during the deposition of the Frontier Formation prior to 58 million years ago. There are no significant landslide or subsidence areas in the Three Mile Canyon area.

6.3 HYDROGEOLOGY

Groundwater occurs in two main aquifers at the site; a shallow perched water zone and a deeper aquifer. Perched water has been encountered at depths of 19 to 25 feet below the original ground surface as shown on Figure 6, Hydrogeologic Cross Section A-A'. This water zone occurs in the upper sections of bedrock underlying the site and is derived principally from snowmelt and storm water runoff. The direction of flow of the perched aquifer follows the topography, flowing southeast into the colluvial soils of Three Mile Canyon, the east toward Rockport Reservoir, as shown on Figure 5, Hydrogeologic Map.

The top of the deeper aquifer occurs from 36 to 65 feet below the original ground surface. Multiple layers of siltstone are encountered between the surface landfill operation and the deeper aquifer. The aquifer flows toward the Weber River Valley and associated alluvial deposits to the east. However, there is evidence that although the area groundwater gradients flow to Rockport Reservoir, the reservoir is locally recharging the groundwater system. The groundwater gradient across the site ranges from 0.07 to 0.1 ft/ft. The principal sources of recharge are likely to occur by direct precipitation within the basin and from surface runoff from the surrounding slopes. Infiltration into exposed rock outcrops also convey to the aquifer.

6.4 GROUNDWATER QUALITY

Groundwater at the site has been routinely analyzed since landfilling operations began. There are presently three wells that are monitored at the site, including two downgradient wells (MW-3 and MW-7) and one upgradient well (MW9). The original upgradient well, MW-8, was destroyed during landfilling operations. A new upgradient well, MW-9, was installed in 1994 (drilling log and well completion details are included in Appendix B). The groundwater monitoring events have been performed at the landfill from 1985 to 2003. The analytical data from these groundwater monitoring events are on record at the UDSHW.

6.5 SURFACE WATER

Three Mile Creek, located approximately 1000 feet south of the site, is an intermittent stream, which flows into Rockport Reservoir. The stream drains most of Three Mile Canyon and receives the runoff from the landfill. It is considered to be water quality limited by state standards. Diversion swales have been constructed around the landfill, which route the surface drainage through a catch basin. The principal reason for the catch basin is to remove errant litter from the flow prior to exiting the site.

Rockport Reservoir is located approximately one half mile to the east of the site. TDS concentrations within the reservoir range from 100 to 300 mg/L.

6.6 WATER RIGHTS

A search of water rights on file with the Department of Natural Resources has been conducted for a radius of 2000 feet from the site. The nearest well on record is located 1250 feet south of the site, belonging to the Utelite Corporation. No other wells are within 2000 feet of the site.

6.7 SITE WATER BALANCE

The amount of water that will percolate though a landfill and eventually reach the water table is a function of the amount of water applied to the landfill over, the evaporation at the site, the permeability characteristics of the landfill, and the soil profile. The HELP (Hydrologic Evaluation of Landfill Performance) model was used to estimate the amount of precipitation that would percolate through the soil profile (Class I Municipal Solid Waste Landfill Application, 1997).

Landfill performance was modeled using conservative values of climatological data, soil profile characteristics and surface drainage. The following assumptions and data were used for input into the HELP model:

- HELP is used to model post-closure condition
- Precipitation and temperature records from Wanship Dam for the period 1955 to 1992
- Use evaporation values in database (Salt Lake City)
- Depth to water table is 50 feet
- Modeling period – 30 years

The average annual precipitation for the period of record was 16.06 inches. Based on this precipitation, HELP calculates the water balance for the site, which includes; evapotranspiration, runoff, percolation, and change in water storage of the subsurface soils. Average annual values for 30 years for evapotranspiration was 14.39 inches with a runoff of 1.03 inches per year. Percolation through the vadose zone below the landfill was calculated to be 0.62 inches. Results of the HELP modeling are presented in Appendix C.

6.8 GROUNDWATER MONITORING PROGRAM

6.8.1 Groundwater Monitoring Well System

Groundwater will be monitored during the active phase of the landfill, and during the post-closure period of 30 years. Three groundwater wells are presently being monitored at the site, including two downgradient wells (MW-3 and MW-7) and one upgradient well (MW-9). The former upgradient well, MW-8, was destroyed during landfilling operations. The new upgradient well, MW-9 was installed in 1994. The wells have been completed according to EPA protocol, and well logs and completion details are included in the Groundwater Monitoring Plan (Appendix B).

The upgradient well is located near the western edge of the landfill and is used to collect groundwater representative of background water quality. From the upgradient well, the hydraulic gradient generally follows the topographic contours to the east and southeast. The two downgradient wells are located hydraulically downgradient of the landfill and are considered points of compliance.

Groundwater at the site has been routinely analyzed since landfilling operations began. The groundwater quality results for five of the monitor wells at the site have been submitted and on fill at the UDSHW.

6.8.2 Sampling Procedures and Analysis

Sampling of the compliance wells and the background well will be performed on a semi-annual, or if required by UDSHW on a quarterly basis, by personnel familiar with correct sampling procedures and in conformance to the approved Groundwater Monitoring Plan (See Appendix B). All sampling equipment will be disposable or shall be properly decontaminated between sampling points using an Alconox detergent wash, and triple-rinsed with distilled water.

The groundwater surface elevation, pH, temperature, and conductivity shall be measured and recorded at the time of sampling on the groundwater monitoring form (included in Attachment 2 of the Groundwater Monitoring Plan provided in Appendix B). The samples will be kept on ice and delivered under chain-of-custody to a State-Certified analytical laboratory. Field QA/QC shall consist of a field duplicate from one of the compliance points. The duplicate shall be given a separate identification number and transported with the other samples.

Since May 2002, assessment monitoring is being performed on the monitor wells and following the requirements outlined in UAC R315-308-2(11). Groundwater samples will be analyzed for constituents summarized in the Groundwater Monitoring Plan provided in Appendix B, using the specified methods and detection limits. After assessment monitoring is completed a detection monitoring program would be performed.

The groundwater samples for detection monitoring will be analyzed for the heavy metals and inorganic constituents summarized in the Groundwater Monitoring Plan provided in Appendix B, using the specified methods and detection limits. In addition to these compounds, EPA laboratory test methods 624 and 625 for volatile and semi-volatile organic compounds are to be tested once every three years. Analysis shall continue for these constituents according to this schedule throughout the 30-year post-closure period.

6.8.3 Groundwater Quality Protection Standards

The groundwater classification system established in the State of Utah Groundwater Quality Protection Regulations designated the groundwater as Class I Drinking Water Quality Groundwater, based on background total dissolved solids (TDS) less than 500 mg/l. The groundwater quality protection standard for all constituents in the compliance wells shall be the groundwater quality standards in Table 1 of UAC Subsection R317-6-2.

In 2002 concentrations of certain metal constituents in the downgradient wells showed a significant increase as compared to the upgradient well (MW9). Therefore, assessment monitoring is being performed on the monitor wells and following the requirements outlined in UAC R315-308-2(11). After assessment monitoring and groundwater statistical analysis is completed the landfill may require *corrective action* ~~of~~ or return to Detection Monitoring.

During detection monitoring if any constituents exceed the groundwater protection standards the Executive Secretary must be notified within 14 days of this finding in writing. The data and sampling procedures will be reviewed to determine if the exceedence is due to errors in the analytical data. If it is determined the data is valid the wells will be re-sampled and quarterly assessment monitoring may be required.

7. ENGINEERING REPORT

7.1 LOCATIONS STANDARDS

7.1.1 Land Use Compatibility

The Three Mile Canyon landfill site meets the following location standards:

- It is not within 1,000 feet of any park, recreation area, or wilderness area.
- It is not within any wildlife management areas, or "prime" or "unique" farmland.
- It is not within one-forth mile of permanent dwellings, residential areas, schools, churches, or historic structures.
- It is not within 10,000 feet of any airport runway.
- No archeological sites are nearby.

7.1.2 Geology

The facility is not located in an unstable area and no subsidence or landslides have been noted in the area. The stability of the embankment was modeled using PCSTABL5M. The computer program was developed at Purdue University to model the static and pseudo-static (earthquake) stability of slopes. The factor of safety against instability of the slope is calculated using the method of slices. There are several types of method of slices analysis available; the type used for this evaluation was the Simplifies Bishops Method, which is appropriate for circular shaped failure surfaces. Potential failure surfaces are generated from random locations across the critical area at the toe of the slope. A total of 800 trial failure surfaces are generated for each run. The program provides output for the ten surfaces with the lowest factor of safety. The program requires site-specific input data including:

- Soil profile
- Soil strengths
- Seismic data

The soil profile used for stability analysis was a cross section of the steepest area of the embankment, and including the future final slope of the waste placement. The berm has a slope of 3:1. The final design plans for the landfill requires that the slope of any subsequent berm construction be at a 3:1 slope. The cross section used in the model is provided in Appendix C.

Assumed soil strength values include a cohesion and friction angle. Based on information obtained from previous site investigations, the site soil has been determined to be a silty clay or clay soil. The strength values assumed for the soil used in the berm were obtained from typical values found in literature for re-compacted soils. Values of cohesion for a silty clay or clay range from 1,300 to 2,000 pounds per square foot (psf); a conservative cohesion of 1,500 was used. Friction angles range from 27(degrees) to 34 (degrees); a conservative value of 29 (degrees) was used.

The landfill is located in a seismic impact zone as defined in the Rules: the area has greater than a 10% chance of exceeding an acceleration of 0.1 g in 250 years. Seismic acceleration maps, and site specific fault information for Wanship dam, were used to evaluate the potential earthquake induced acceleration at the site. A general acceleration map for the United States shows the acceleration at the site with a 10% chance exceedence in 250 years to be 0.50 g (Algermissen,1982). A similar map developed specifically for the Wasatch Front shows an acceleration of approximately 0.03 g at the site (Youngs, 1987). The Safety Evaluation of Existing Dams (SEED) Reports for Wanship Dam (1990), located 2 miles from the landfill, rigorously identified all local faults and expected Maximum Credible Earthquake (MCE) for each fault. The acceleration from each fault was calculated based on the Fault's MCE, the distance from the landfill, and attenuation curves (Seed, 1969). The maximum acceleration of 0.30 g was used in the pseudo-static stability analysis of the embankment slope at the site.

Based on the assumed profile, soil strengths, and earthquake loading, the minimum factor of safety computed by PCSTABL5M for the embankment during an earthquake was 1.5. The minimum factor of safety computed by PCSTABL5M for the static case was 3.1. Results from PCSTABL5M runs and the assumptions used for determining input into the program are presented in Appendix C.

7.1.3 Surface Water

The site is not located in an existing floodplain.

7.2 SOLID WASTE MANAGEMENT PLAN

It is assumed for the basis of this permit application that the existing Three Mile Canyon landfill will receive waste for the next 10 years from all of Summit County. The current population for the county is approximately 32,831, with a projected additional increase of 43,464 by the year 2011. Based on the population projection, an additional 518,214 tons of solid waste will be disposed at the site. The total area of the site is 23.6 acres.

The total volume of Class I & IV solid waste that could be disposed of at the Three Mile Canyon site, based on the final projected grade at closure, is approximately 1,036, 400 yds^3, which exceeds what is anticipated to be generated in the next 10 years by the projected population being served by the landfill. The extra capacity can be used as a buffer for any unexpected increases in waste disposal due to unforeseen increases in population, increases in disposal rate or the addition of other areas that will use at the site.

7.3 CELL DESIGN AND DEVELOPMENT

The Landfill has one cell, which will be used under the existing permit for disposal of municipal solid waste (). An active working cell is the area within the permitted cell that is actively receiving waste during a day (which has not yet had daily cover placed). The future working face of the landfill will be constructed and maintained to a maximum 3:1 horizontal to vertical slope.

The existing and future landfill design will consist of compacted natural clay underlying all waste disposal areas. As the landfill progresses to the west into the hillside, waste cells will be constructed according to the details presented on Figure 4.

The waste will be unloaded at the base of the working face and will be spread over the working face by a track-mounted dozer or steel-wheeled compactor. All waste will be compacted prior to placement of daily cover (minimum 6-inches). The daily cover material will consist of soil from the cell expansion. Unloading of waste will be restricted to one area of the working face to limit vehicular traffic and to limit the amount of waste exposed and requiring daily cover.

Once the cell is completed a final cover will be constructed with a minimum three percent grade and the surface will be re-vegetated. The final cover will consist of 18 inches of compacted clay available from the existing stockpiles of native soil. A 6-inch thick topsoil layer will then be placed over the compacted clay layer. The topsoil also will be available from the stockpiled materials.

The Landfill will be operated with a minimum of two pieces of heavy equipment; a crawler-dozer and a compactor. These units are currently being utilized by Summit County Landfill personnel, and may be augmented as necessary with additional equipment, such as graders and loaders, from the Summit County Road Department.

The landfill facility will have a utility truck capable of moving around the site during inclement weather and powerful enough to pull small trailer-mounted equipment, which may be needed at the site. This vehicle will carry whatever tools are necessary for routine maintenance of the heavy equipment. Auxiliary equipment at the site may include a small portable water tank for wetting the roads or washing equipment.

7.4 DISCUSSION OF RUN-ON AND RUN-OFF CONTROL SYSTEMS

Run-on/run-off controls will be implemented prior to construction of the final cover to prevent run-on to and run-off from the active portion of the landfill. The active area of the landfill is considered to be any area with exposed waste, or any area that has previously received waste and is capped with daily cover only. Run-on/run-off controls will also be constructed as part of the final design to minimize potential erosion of the final cover and embankment. The proposed storm controls are designed to manage run-off from a 25-year, 24-hr storm.

Prior to construction of the final cover, all run-off from the active area will be retained and not allowed to flow off site. Run-off from areas of the landfill with intermediate cover will be routed through the existing detention basin prior to discharge to the existing channel. Currently, run-off from the interactive area of the cell is discharged from the north side of the landfill near where the access road enters the site. The intermediate cover shall continue to be sloped toward the north as the waste lifts are placed until the final elevation of the final cover is reached.

Runoff from the final cover will be collected in the perimeter diversion swales located and routed to the existing drainage channel located southeast of the disposal cell. The final cover is designed to reduce runoff, promote evapotranspiration, and minimize percolation into the waste by providing a vegetated low-permeability final cover.

There does not appear to be any potential for dry-weather flow at the landfill site. Municipal waste disposed in the landfill will not produce any significant quantity of free liquid. Sludge previously deposited in the sludge disposal area was stabilized and did not produce any free liquids.

7.4.1 STORM Modeling

Storm water run-off calculations were performed to determine the run-off volume and maximum flow rates. The run-off was determined for the area immediately upgradient (west) of the landfill, the drainage basin located northwest of the landfill that flows into the existing drainage channel north of the landfill, and the active and post-closure conditions of the landfill. The computer program STORM was used. STORM uses the Soil Conversation Service method to determine run-off from the designated precipitation event. The precipitation for the 25-yr, 24-hr storm event was estimated from NOAA Atlas 2 "Precipitation Frequency of Western United States" (1973) to be 2.5 inches.

The total area within the permit boundary is approximately 28 acres with a disturbed area of 23.6 acres and an undisturbed (no construction) are of 4 acres. The disturbed areas were assumed to be uncompacted native soil with no vegetation. Each area with a unique soil type, in the surrounding drainage basin, was molded separately. Assumptions used in storm water run-off modeling are presented in Table 3. Specific of STORM modeling are included in Appendix C, Engineering Calculations.

TABLE 3
"STORM" INPUT VALUES

PARAMETER	LANDFILL	DRAINAGE BASIN[1]
Precipitation event	2.5"	2.5"
CN[2] disturbed area undisturbed area	80[3] 67	NA Varies (46 to 67)
Area	28 acres	200 acres
Time of concentration	0.10 hr[4]	Varies (0.10 to 0.36) hr

NA: Not Applicable
(1) Area of drainage basin – area of the waste disposal area
(2) From Viessman, *"Introduction to Hydrology"*, 1989
(3) Assumed value
(4) Minimum time of concentration allowed in STORM

The maximum run-off discharge rates were determined in order to design storm water control structures that would safely pass the 25-yr, 24-hr storm, without and adverse impacts to the landfill. STORM results are presented in Table 4.

TABLE 4
"STORM" OUTPUT

AREA	MAXIMUM DISCHARGE (cfs)	TOTAL Run-off VOLUME (acre-ft)
Area west of landfill [1]	8.0	0.6
Entire drainage basin minus landfill area[2]	27	3.6
Landfill area	35	2.1
Total	70	6.3

(1) The area west of the cell that flows into the existing diversion swale
(2) Basin that the landfill is located in minus the waste disposal area

As shown in the tables, the predicted maximum discharge rate from the smaller-area landfill is equal to the discharge from the remainder of the drainage basin. This is due to the fact that a large percentage of the landfill has been stripped of vegetation, which increases run-off. Also, because of the relatively small area of the landfill the maximum discharge peaks at one time, while the flow from the entire basin is attenuated.

Currently, run-off from areas that have been disturbed pass through the existing detention pond. The detention pond slows the water down and allows sediment in the run-off to be deposited in the basin. Most is removed and is not discharged through the outlet of the detention basin. Additional storm water controls described in Section 7.4.2, are required to control run-on/run-off from the specified precipitation event.

7.4.2 Active-Phase Storm Water Controls

Currently, storm water run-off is managed through the existing control structures of diversion swales, culverts, and detention pond, and construction of bermed waste subcells. These controls are designed to divert, convey, and detain storm water in order to minimize contamination of the storm water. With the exception of the waste sub cells, all controls will be implemented during the active phase and will remain in place during the post-closure period.

7.4.2.1 Waste Cells

Waste sub cells will be used to control run-on/run-off impacting the active areas within the disposal cell. These sub cells will be constructed as shown on Figures 2 and 4 and are designed to totally contain run-off and to prevent run-on into the active waste placement area. Precipitation that falls on the exposed waste within the active sub cell will be retained by the earthen berms constructed around the sub cell, and will be contained within the active area.

In order to minimize the amount of water that could potentially infiltrate into the waste, the waste sub cells will be confined within and area of 1 acre or less. The rest of the landfill area will have intermediate or final cover over the waste, and the run-off from these areas will flow to the north where it will be discharged into the natural drainage channel and subsequently routed through the detention pond. The use of waste sub cells will allow for storm water that potentially comes into contact with the waste to be captured and contained.

7.4.2.2 Detention Basin

All water flowing in the drainage channel located along the north edge of the landfill is routed through the existing detention pond located at the southeast corner of the landfill. The drainage channel collects run-off from the drainage basin west and north of the landfill, and from inactive areas in the landfill itself. All run-off from inactive disturbed areas of the landfill is routed through the detention pond. The detention basin slows the water, allowing sediments to drop out of suspension.

The east embankment of the landfill forms one side of the detention pond, with the natural channel side slope forming the other side. The detention pond dam is located near the southeast corner of the landfill. A 24" corrugated metal pipe (CMP) outlet placed near the top of the dam structure discharges into the natural channel below the dam. The capacity of the detention pond to the level of the outlet structure is 100,000 ft^3. Small precipitation events will be contained completely within the detention ponds with no discharge from the outlet. The pond will detain the run-off from a 25-yr, 24-hr storm for a minimum of 25 minutes before discharging the storm water. This detention time should be sufficient for the majority of the suspended solids to settle out of the run-off.

7.4.2.3 Culverts

The access road constructed by Summit County in the spring of 1996 has had culverts installed under the road. The installed culverts pass flow from the small dry washes north of the landfill and drain into the existing drainage swale located along the north edge of the landfill. Other culverts shall be installed under the existing road in the locations shown on Figure 3 to transport run-off under the roadway. The culvert sizing calculations are included in Appendix C. The culverts consist of CMP ranging in diameter from 18 inches to 36 inches. The culverts shall be installed using Class C bedding.

7.4.3 Post-Closure Storm Water Controls

The Post-closure storm water controls are designed to prevent adverse impacts to the final cover or embankment during the post-closure period.

7.4.3.1 Upgradient Diversion Swale

Surface run-on from upgradient (west) of the site is currently controlled by an existing diversion swale that is located approximately 100 feet west up slope of the permit area. This diversion swale is a relatively flat area that has been graded into the side of the mountain and slopes slightly into the hillside. The hill above the landfill is covered with sagebrush, and sheet flow from the hill is captured along the length of the diversion swale. The run-on is diverted around the landfill with approximately half of the potential run-on flowing to the north where it is discharged into the natural drainage channel; and half of the potential run-on flowing south where it is currently discharged to the ground surface south of the landfill, eventually flowing to Three Mile Canyon Creek (see Figure 3).

7.4.3.2 Perimeter Drainage Swales

Run-off from the final cover will be collected in drainage swales located around the perimeter of the landfill (see Figure 3). The swales are designed with a maximum side slope of 2:1 and minimum depth of 1.5 feet. Design details are discussed in the engineering calculations in Appendix C. The drainage swales will be excavated in native soil. Riprap will cover the surface of the drainage swales in areas where the slope is greater than 5%. Water velocities in these areas are greater than 6 feet per second, which could cause erosion of the channel. Riprap sizing calculations are also included in Appendix C and riprap specifications are listed as follows:

Rock Diameter	% Passing by Weight
12"	100%
6"	40-60%
2"	<10%

7.4.4 Erosion Potential

In order to elevate the long term performance of the landfill cover in terms of durability and integrity, the potential for erosion from the cap was calculated for both water and wind erosion. The reference used for these calculations is "Erosion Control During Highway Construction – Manual on Principals and Practices", National Cooperative Highway Research Program Report No. 221, Transportation Research Board.

Based on calculations using the Universal Soil Loss Equation, the potential erosion due to water is 1.5 tons/acre/year, resulting in approximately 0.0006 feet per year removed from the final cover. Wind erosion calculations indicate the potential of 0.68 tons/acre/year, resulting in approximately 0.00028 feet per year removed from the final cover. These calculations, which are presented in Appendix C, indicate that the vegetative layer will effectively protect the landfill cover from long term erosion over the length of the post-closure period.

7.5 CLOSURE AND PST-CLOSURE DESIGN AND MAINTENANCE

The closure of the landfill operations at the Three Mile Canyon Landfill will minimize the need for further maintenance; minimize the threats to human health and the environment from post closure escape of solid waste constituents, leachate, landfill gases, contaminated run-off or waste decomposition products to the groundwater, surface water or the atmosphere; and prepare the facility or unit for the post closure period.

To facilitate the minimization of maintenance and the minimization of threats to human health or the environment, a design plan for final cover and grading has been prepared (see Figure 3). The landfill will be covered with a final design cover which will consist of an 18 inch compacted silty clay layer and a final 6 inch topsoil cover.

Material testing was performed on samples of the silty clay material at the site, which is used for the bottom liner and cover of the landfill. The following tests were performed on the representative sample:

- Washed sieve
- Hydrometer
- Atterberg Limits
- Standard Proctor test (ASTM D698)
- Permeability

Based on the results of the Proctor test, two samples were remolded for permeability tests. A sample representing the bottom liner of the landfill was compacted to approximately 91% of the maximum dry density of the material (the target density of the sample was 90% of the maximum dry density), at a moisture content of 2.7% below optimum. A sample representing the cover liner of the landfill was compacted to 95% of the maximum dry density, at a moisture content of 2% to 3% above optimum.

The north, south, and east-facing slopes of the berm will be constructed in 2004 of filled material without rocks larger than six inches in size to a depth of 10 feet. This material will be allowed to consolidate in place and remain undisturbed throughout the remaining life of the cell..

Samples of the berm were collected in November and December 1996 and permeability tests were performed by Bingham Engineering's soils laboratory. A standard Proctor test was performed on the material and the results indicated a maximum dry density of 108.5 pounds per cubic foot (pcf) and an optimum moisture content of 18%. Three samples were then compacted to 87, 90 and 100 percent of the Proctor maximum dry density, respectively, then tested within a falling head permeameter. The results are summarized in the following table.

TABLE 5
PERMEABILITY VALUE FOR THE BERM SOILS

Relation to Standard Proctor	Compaction Density	Moisture Content	Permeability
100% of Maximum Dry Density	108.5 pcf	23.50%	2.7×10^{-6} cm/sec
90% of Maximum Dry Density	97.7 pcf	21.00%	7.0×10^{-6} cm/sec
87% of Maximum Dry Density	91.8 pcf	18.90%	4.7×10^{-5} cm/sec

Based on the original plans, the berm material was to be compacted to a minimum of 90% pf the maximum dry density. These recent test results could then suggest permeability less than 7.0×10^{-6} cm/sec.

A computer program solving the modified Berggren solution was used to predict the frost penetration of the final cover. Four modeling runs were conducted, using two separate soil types with and without snow cover. The first two model runs used data from the berm material, and the second two used the natural soil, which will be compacted for the cover. The input parameters and the associated results are summarized in the following table.

TABLE 6
PREDICTED FROST PENETRATION OF THE COVER

Layer Thickness	Moisture Content	Dry Density	Frost Penetration
24 inches (no snow)	24%	93 pcf	26.5 inches
24 inches (with 6" snow cover)	24%	93 pcf	2.5 inches
24 inches (no snow)	15%	110 pcf	31 inches
24 inches (with 6" snow cover)	15%	110 pcf	3.1 inches

As indicated in the table, if no snow cover is assumed, frost penetration could reach a depth of 2.5 feet; however, it is reasonable to assume at least 6 inches of snow cover during the coldest part of the winter season. A 6-inch snow cover provides an insulating layer that keeps frost from penetrating through the cover and compromising the permeability of the final cover. Frost Penetration Calculations are included in Appendix C.

Deep-rooted vegetation will be discouraged through substitution of shallow-rooted vegetation. The seed mixture specified in the Application consists of grasses and forbs having relatively shallow root systems. Root penetration into the cover is not expected to be deep enough to compromise the permeability of the cover based on the specified seed mixture.

season. A 6-inch snow cover provides an insulating layer that keeps frost from penetrating through the cover and compromising the permeability of the final cover. Frost Penetration Calculations are included in Appendix C.

Deep-rooted vegetation will be discouraged through substitution of shallow-rooted vegetation. The seed mixture specified in the Application consists of grasses and forbs having relatively shallow root systems. Root penetration into the cover is not expected to be deep enough to compromise the permeability of the cover based on the specified seed mixture.

The compacted silty clay layer will have a maximum field permeability of 5×10^{-7} cm/sec. The topsoil will be re-vegetated as soon as practical after the completion of the final cover with the following seed mixture (or equivalent) specified by the Department of Transportation for local area right-of-ways:

Smooth brome	8 lbs PLS/acre
Fairway wheatgrass	8 lbs PLS/acre
Slender wheatgrass	4 lbs PLS/acre
Sheeps fescue	4 lbs PLS/acre
Sodar wheatgrass	4 lbs PLS/acre
Spreader II alfalfa	4 lbs PLS/acre
Wood fiber hydromulch	2000 lbs/acre
Tackifier	500 lbs/acre

The waste disposal cell is expected to experience some settlement. However, the closure plan is designed to maintain a positive drainage off the trench area throughout the closure period. The majority of settlement will take place during and prior to final grading and cover placement. The final grades will be constructed to a minimum 3 percent slope on the top of the cell. All run-off will be directed off and around the disposal cells. The entire site will be constructed with a perimeter drainage system, which will minimize any run-off from the adjacent hillsides from contacting the waste cells.

During the post closure period the cover shall be inspected bi-annually. Maintenance of slopes, drainage channels and covers will be performed as required.

8. REFERENCES

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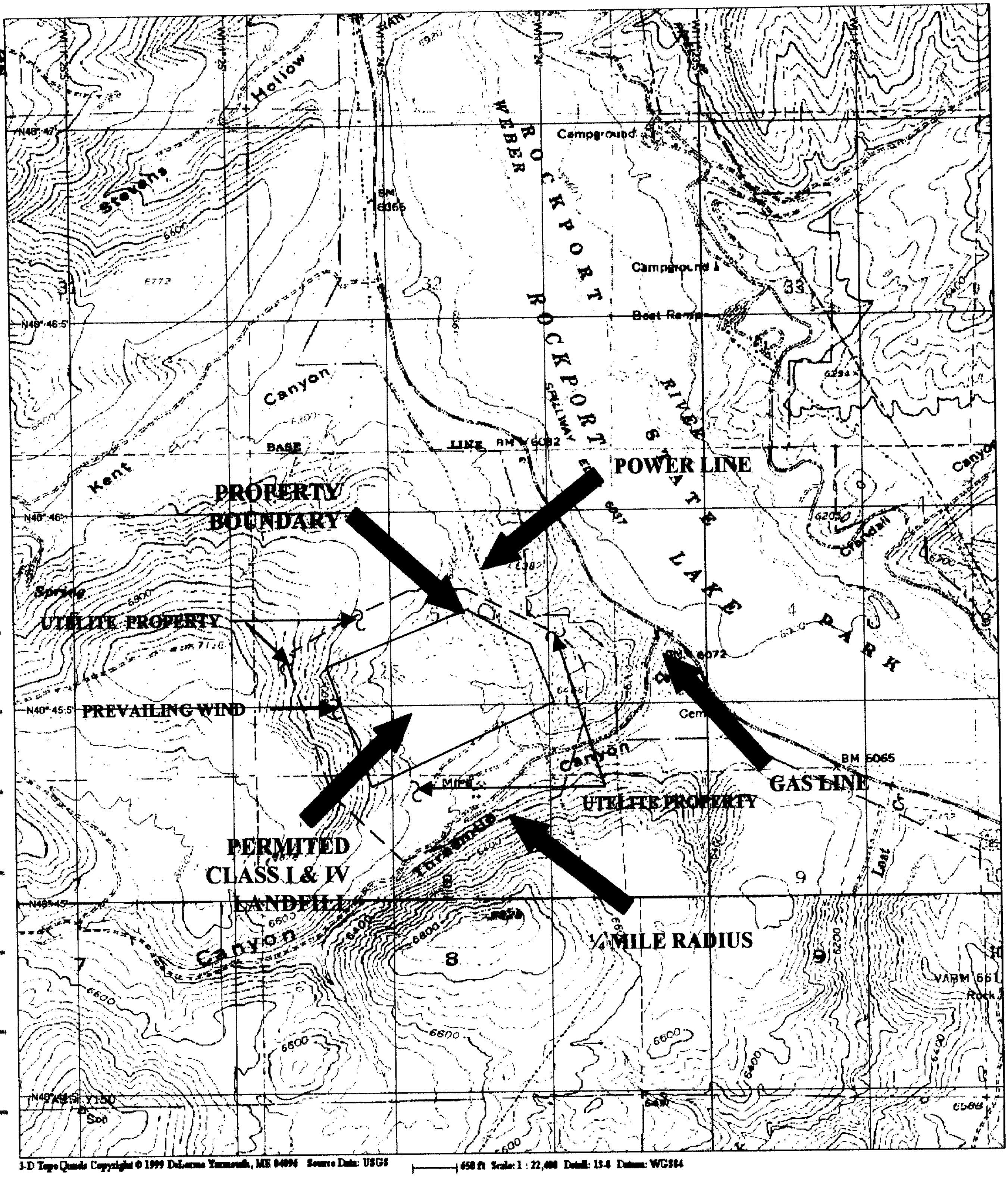


3-D Topo Quads Copyright © 1999 DeLorme Yarmouth, ME 04096 Source Data: USGS 650 ft Scale: 1 : 22,400 Detail: 13-8 Datum: WGS84

ATC ASSOCIATES INC.

2681 Parleys Way, Suite 106
Salt Lake City, Utah 84109
(801) 412-0003

PROJECT NO: 71.25561.3401

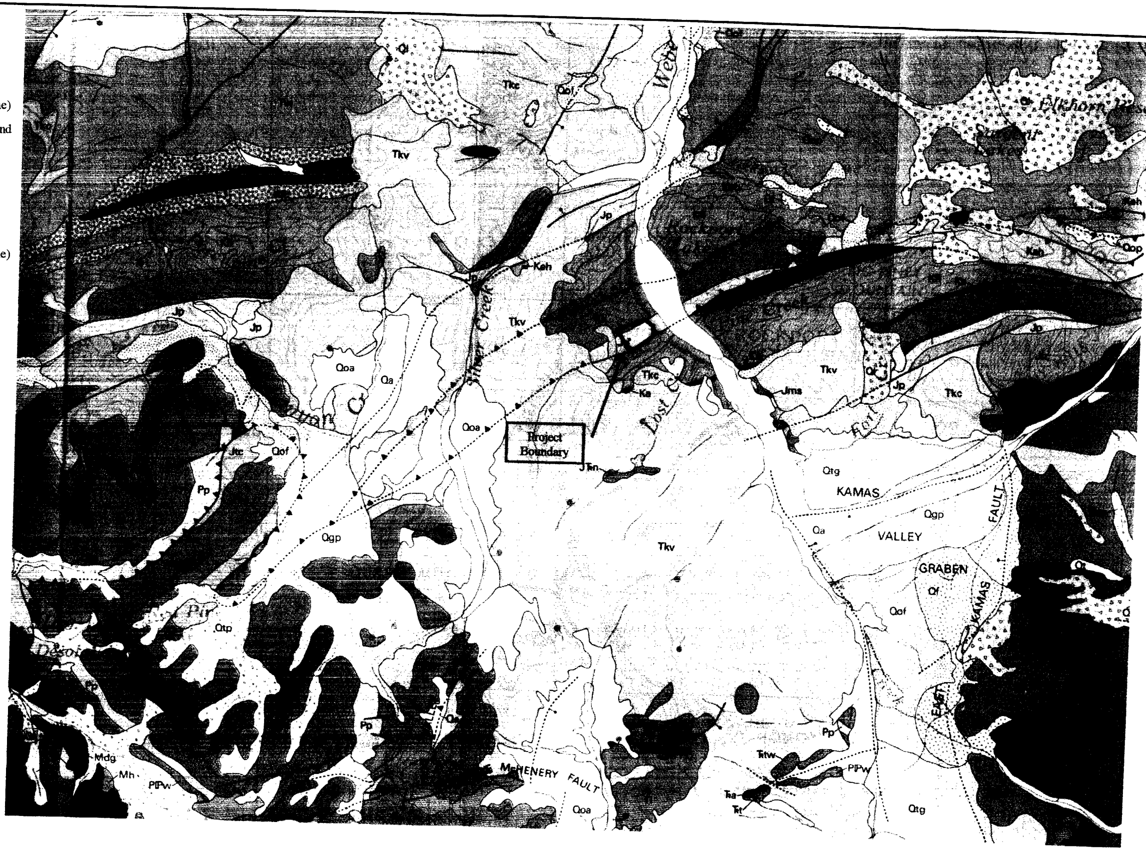
SOURCE: USGS 7.5 minute series, Wanship, Utah Quadrangle, 1999

SITE VICINITY MAP

THREE MILE CANYON CLASS I & IV LANDFILL

FIGURE 1

Qac	Alluvium and colluvium (Holocene)
Qt	Talus and colluvium (Holocene)
Qa	Alluvium (Holocene)
Ql	Landslide deposits (Holocene and Pleistocene)
Qf	Alluvial and debris-fan deposits (Holocene and Pleistocene)
Qoa	Old alluvium (Pleistocene)
Qop	Older pediment deposits (Pleistocene)
Qof	Older alluvial-fan and debris-fan deposits (Pleistocene)
Qgp	Outwash deposits of Pinedale age (Pleistocene)
QTg	Gravel (Pleistocene or Pliocene)
Tkv	Keetley Volcanics (Oligocene and Eocene?)
Tkc	Conglomerate (Oligocene and Eocene)
Tn	Norwood Tuff (Oligocene and Eocene)
	Wasatch Formation (Eocene and Paleocene)
Keh	Hams Fork Member of Evanston Formation (Upper Cretaceous)
Kah	Adaville and Hilliard Formations (Upper Cretaceous)
	Henefer Formation (Upper Cretaceous)
	Upper Member Frontier Formation (Upper Cretaceous)
Kfl	Lower Member Frontier Formation (Upper Cretaceous)
Kfc	Conglomerate Facies Frontier Formation (Upper Cretaceous)
	Aspen Shale (Lower Cretaceous)
Kk	Kelvin Formation (Lower Cretaceous)
	Morrison and Stump Formations (Jurassic)
Jp	Preuss Formation (Middle Jurassic)
Jtc	Twin Creek Limestone (Middle Jurassic)
	Nugget Sandstone (Jurassic? And Triassic?)
	Ankareh Formation (Upper and Lower Triassic)
Tt	Thaynes Limestone (Lower Triassic)
Pp	Park City Formation and related rocks (Permian)



GEOLOGIC MAP OF SITE VICINITY

THREE MILE CANYON CLASS I & IV LANDFILL

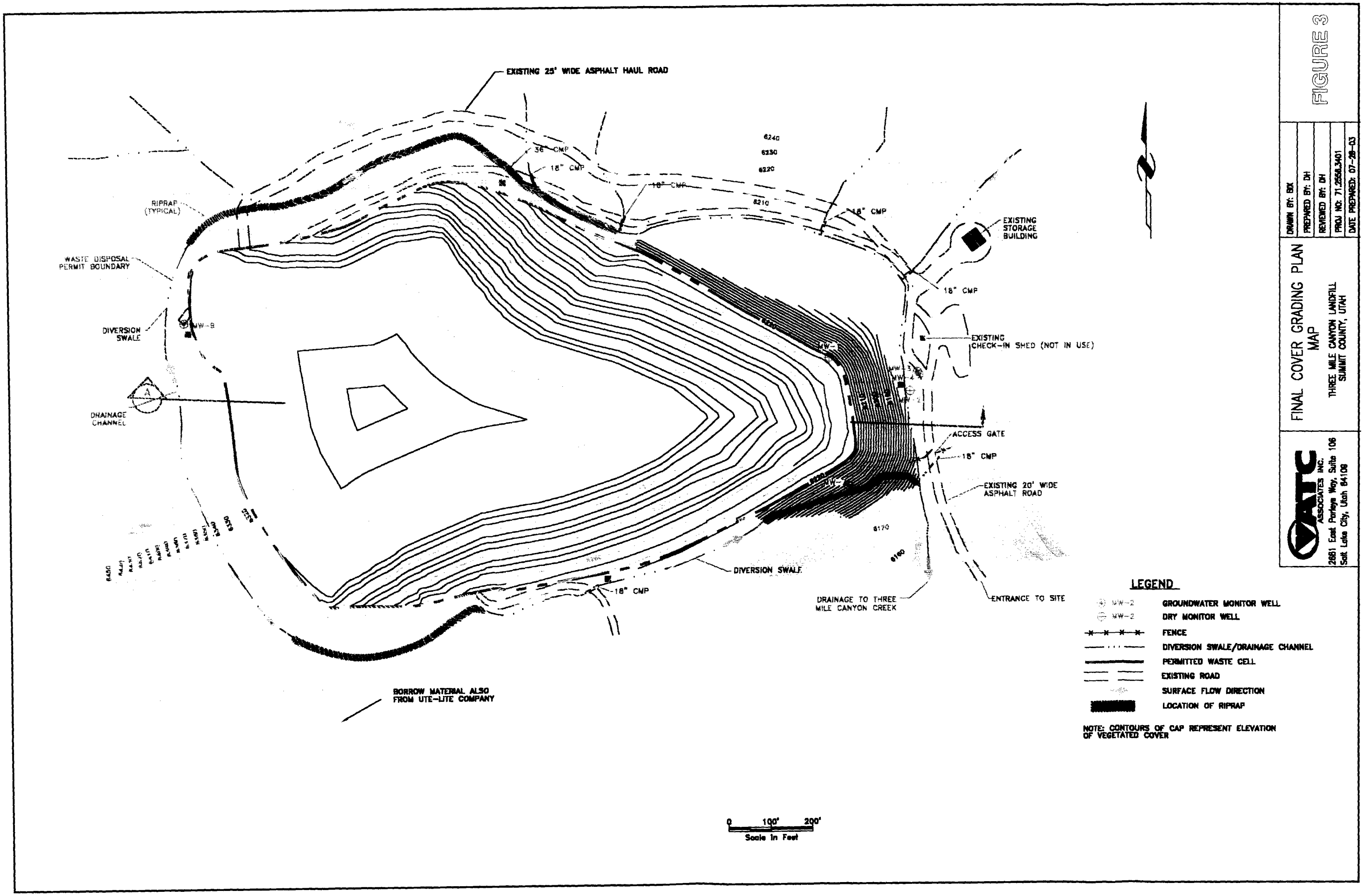
PROJECT NO: 71.25561.3401

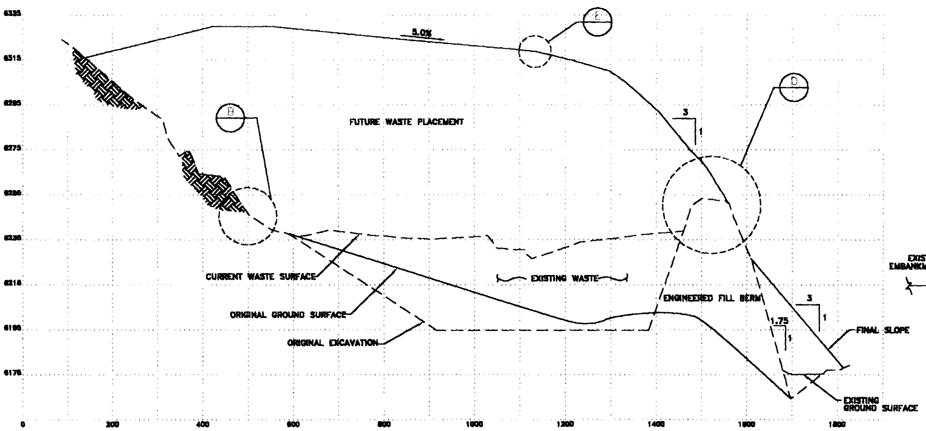
SOURCE: Geologic and Structure Maps of the Salt Lake City Quadrangle, Utah and Wyoming United States Geological Survey Map I-1997, dated 1992

FIGURE 2

ATC Associates Inc.
2681 Parleys Way, Suite 106
Salt Lake City, Utah 84109
(801) 412-0003

ATC ASSOCIATES INC.

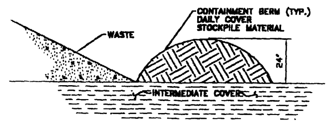

EXISTING 25' WIDE ASPHALT HAUL ROAD
36" CMP
18" CMP
18" CMP
18" CMP
18" CMP
18" CMP
18" CMP
6240
6230
6220
6210
6170
6160
RIPRAP (TYPICAL)
WASTE DISPOSAL PERMIT BOUNDARY
DIVERSION SWALE
MW-8
A
DRAINAGE CHANNEL
EXISTING STORAGE BUILDING
EXISTING CHECK-IN SHED (NOT IN USE)
MW-3
MW-4
MW-2
MW-1
ACCESS GATE
EXISTING 20' WIDE ASPHALT ROAD
DIVERSION SWALE
DRAINAGE TO THREE MILE CANYON CREEK
ENTRANCE TO SITE
BORROW MATERIAL ALSO FROM UTE-LITE COMPANY
0 100' 200'
Scale in Feet
LEGEND
MW-2 GROUNDWATER MONITOR WELL
MW-2 DRY MONITOR WELL
FENCE
DIVERSION SWALE/DRAINAGE CHANNEL
PERMITTED WASTE CELL
EXISTING ROAD
SURFACE FLOW DIRECTION
LOCATION OF RIPRAP
NOTE: CONTOURS OF CAP REPRESENT ELEVATION OF VEGETATED COVER
FIGURE 3
DRAWN BY: BX
PREPARED BY: DH
REVIEWED BY: DH
PROJ NO: 71.2558.3401
DATE PREPARED: 07-28-03
FINAL COVER GRADING PLAN MAP
THREE MILE CANYON LANDFILL
SUMMIT COUNTY, UTAH
ATC ASSOCIATES INC.
2661 East Parleys Way, Suite 106
Salt Lake City, Utah 84109



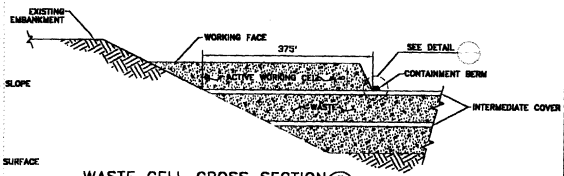
CROSS SECTION A

Scale In Feet
HORIZONTAL SCALE

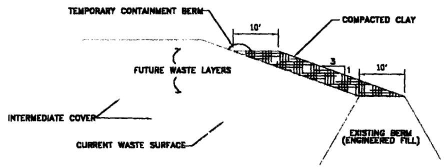
Scale In Feet
VERTICAL SCALE



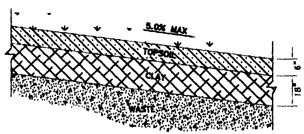
ACTIVE WORKING CELL
SURFACE DRAINAGE
CONTAINMENT DETAIL C
(TYP.)
N.T.S.



WASTE CELL CROSS SECTION B
(TYP.)
N.T.S.



D N.T.S.



COVER DETAIL E
N.T.S.

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ASSOCIATES INC.
2681 East Parleys Way, Suite 106
Salt Lake City, Utah 84109

CROSS SECTION AND DETAILS

THREE MILE CANYON LANDFILL
SUMMIT COUNTY, UTAH

DRAWN BY: BIX
PREPARED BY: DH
REVIEWED BY: DH
PROJ NO: 71.2556.3401
DATE PREPARED: 07-28-03

FIGURE 4

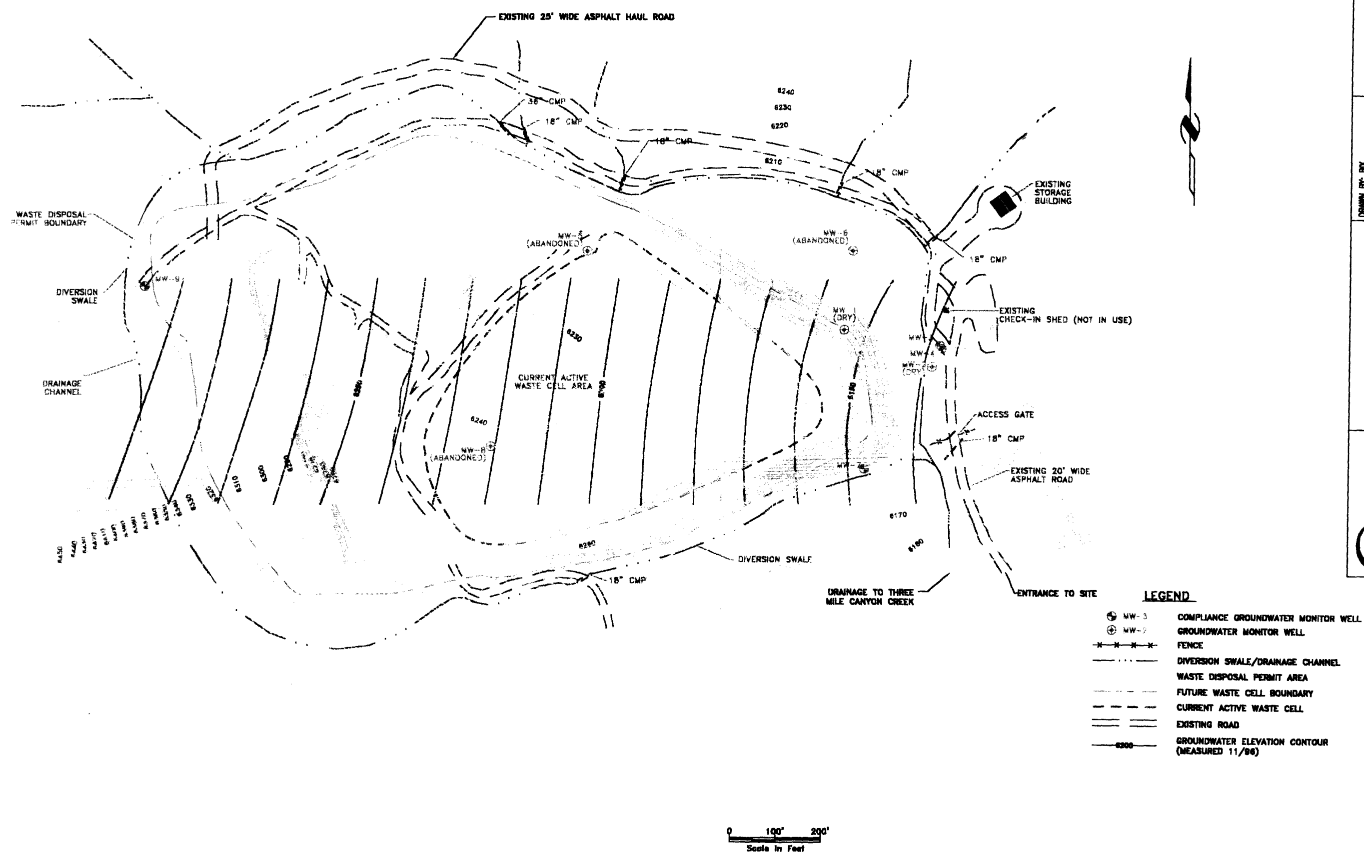
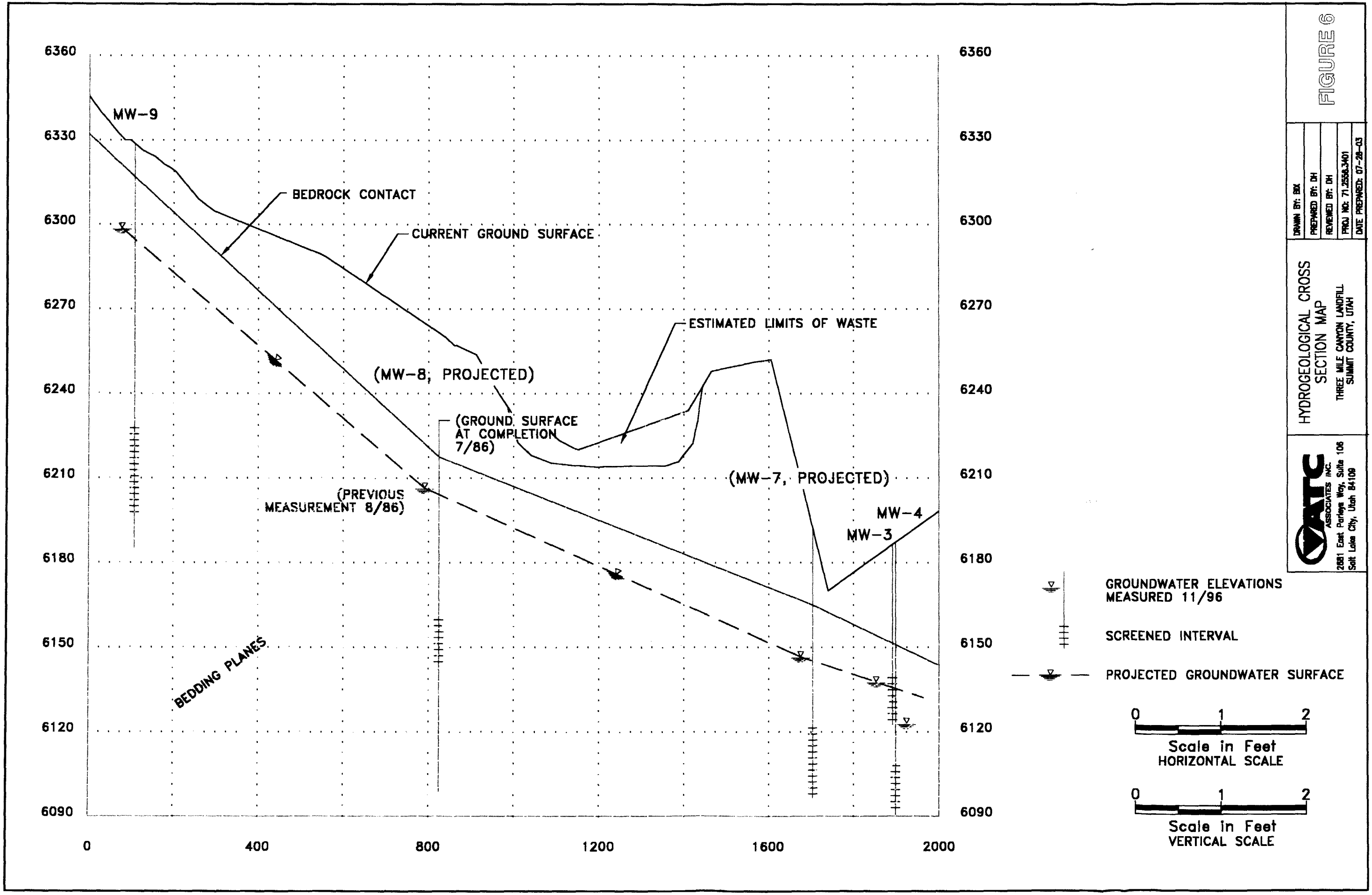


FIGURE 5

DRAWN BY: BDX
PREPARED BY: DH
REVIEWED BY: DH
PROJ NO: 71.2558.3401
DATE PREPARED: 07-28-03

HYDROGEOLOGIC MAP
THREE MILE CANYON LANDFILL
SUMMIT COUNTY, UTAH

ATC ASSOCIATES INC.
2681 East Parleys Way, Suite 106
Salt Lake City, Utah 84109



MW-9
BEDROCK CONTACT
CURRENT GROUND SURFACE
ESTIMATED LIMITS OF WASTE
(MW-8, PROJECTED)
(GROUND SURFACE AT COMPLETION 7/86)
(PREVIOUS MEASUREMENT 8/86)
(MW-7, PROJECTED)
MW-4
MW-3
BEDDING PLANES
6360
6330
6300
6270
6240
6210
6180
6150
6120
6090
0
400
800
1200
1600
2000
GROUNDWATER ELEVATIONS MEASURED 11/96
SCREENED INTERVAL
PROJECTED GROUNDWATER SURFACE
0 1 2
Scale in Feet
HORIZONTAL SCALE
0 1 2
Scale in Feet
VERTICAL SCALE
FIGURE 6
DRAWN BY: BDX
PREPARED BY: DH
REVIEWED BY: DH
PROJ NO: 71.25563401
DATE PREPARED: 07-28-03
HYDROGEOLOGICAL CROSS SECTION MAP
THREE MILE CANYON LANDFILL
SUMMIT COUNTY, UTAH
ATC ASSOCIATES INC.
2681 East Parleys Way, Suite 106
Salt Lake City, Utah 84109

APPENDIX A

SITE INFORMATION

PROOF OF OWNERSHIP

WHEN RECORDED, MAIL TO:

Grantee

S-9449

REQUEST OF Summit County
FEE ALAN SPRIGGS, SUMMIT CO. RECORDER
$ N.C.
RECORDED 3-19-86 at 11:50 M

Space Above for Recorder's Use

Warranty Deed

(Corporate Form)

UTELITE CORPORATION, a Utah Corporation , ~~a corporation~~

organized and existing under the laws of the State of Utah, with ite principal office at , of County of , State of Utah,

grantor, hereby conveys and warrants to SUMMIT COUNTY , Grantee,

of for the sum of

TEN AND NO/100-- DOLLARS,

(and other good and valuable consideration)

the following described tract of land in Summit County,

State of Utah:

See Exhibit "A" attached hereto and by reference made a part hereof.

SUBJECT TO current general taxes, easements, restrictions, and rights of way of record or visible upon inspection.

BOOK 377 PAGE 10 -12

The officers who sign this deed hereby certify that this deed and the transfer represented thereby was duly authorized under a resolution duly adopted by the board of directors of the grantor at a lawful meeting duly held and attended by a quorum.

In witness whereof, the grantor has caused its corporate name and seal to be hereunto affixed by its duly authorized officers this 19 day of March A.D., 19 86.

Attest:

____________________ Secretary.

(Corporate Seal)

UTELITE CORPORATION, a Utah Corporation ~~Company~~

By Carsten N. Mortensen

Vice President.

STATE OF UTAH

COUNTY OF } ss.

On the day of March 1986 , A.D., personally appeared before me Carsten N. Mortensen and ,

who being by me duly sworn, did say, each for himself, that he, the said Carsten N. Mortensen is the Vice president, and he, the said is the secretary of Utelite Corporation, A Utah Corporation ~~Company~~, and that the within and foregoing instrument was signed in behalf of said corporation by authority of a resolution of its board of directors, and said Carsten N. Mortensen and each duly acknowledged to me that said corporation executed the same and that the seal affixed is the seal of the said corporation.

Notary Public

My Commission Expires 11-10-89

Residing at: Heber, Utah

EXHIBIT "A"

The surface estate only, in and to a parcel of land located in the South half of Sec. 5, T.1S., R.5E., S.L.B. & M. being more fully described as follows:

Beginning at a point which falls North 663.21 feet, and West 1,779.79 feet from the Southeast corner of said Section 5, Township 1 South, Range 5 East, Salt Lake Base and Meridian said Section corner is a mound of stone on a North-South fence line; thence North 67°45'49" East 900.0 feet; thence North 12°48'28" West 827.0 feet; thence North 57°30'44" West 1,140.0 feet; thence South 79°30'16" West 2,148.5 feet; thence South 13°47'58" East 1,945.22 feet; thence North 75°06'51" East 2,028.5 feet to the point of BEGINNING. (Hereinafter, the "Landfill Site").

Together with an easement for ingress and egress over along and across a sixty foot wide strip of land located in the S.E. Quarter of Section 5, T.1S., R.5E., Salt Lake Base and Meridian, the centerline of which is more fully described as follows:

Beginning at a point which falls North 367 feet, and West 863 feet from the S.E. Corner of said Section 5, said point falls on the North right-of-way line of an existing county road; thence northwesterly along a curve to the right 136.04 feet, said curve has a central angle of 25°58'58"; thence N. 55°52'24" W. 242.96 feet to a curve to the right; thence northwesterly along said curve 212.32 feet; said curve has a central angle of 40°33'; thence No. 15°19'24" W. 119.18 feet to a curve to the right; thence northwesterly along said curve 5.46 feet to the boundary line of the Summit County landfill; said curve has a central angle of 1°02'34"; said point falls North 841.38 feet, and west 1343.98 feet from said S.E. corner of said Section 5. (Hereinafter, the "Road Right of Way.")

BOOK 377 PAGE 11

Grantor is retaining and excepting from this conveyance its present leasehold interest in and right to mine minerals from the Landfill Site, but Grantor shall not mine under the Landfill Site but may mine under the Road Right of Way.

Grantor shall have and retain, and reserves and excepts from this conveyance an easement and right of way for access and utilities across and through the Landfill Site to Grantor's property east, north and west of the Landfill Site, the location of such easement and right of way to be reasonably agreed to between the Grantor and Grantee.

As a condition of this conveyance, Grantor and Grantee agree that Grantor in the future in order to facilitate its mining may from time to time relocate the access road to the Landfill Site. Grantee hereby agrees to permit Grantor at its expense to relocate said road, except that Grantee at its expense agrees to pave the first 1000 feet of such road relocation.

As a condition of this conveyance, Grantor and Grantee agree that Grantor shall have the right to dispose of a reasonable amount of overburden and waste material, whether natural or manmade, on the Landfill Site. Such overburden and waste material shall be placed in the southeast quarter of the Landfill Site, at the precise location or locations to be reasonably specified by Grantee, unless Grantor and Grantee shall mutually agree otherwise as to a site or sites elsewhere within the Landfill Site for disposal of such overburden. Grantor shall bear all costs of loading, hauling and dumping such overburden and waste material, but Grantee shall not charge Grantor for disposing of such material on the Landfill Site. For purposes of this paragraph, the term "reasonable" as used above shall mean up to 10,000 tons of overburden and waste material per year, and such further yearly amounts as may reasonably be agreed to by Grantor and Grantee.

The terms Grantor and Grantee herein shall include their successors and assigns, and the conditions and agreements herein shall bind and inure to the benefit of Grantor, Grantee and their successors and assigns, and shall run with the land.

Western States Title Company

370 East Fifth South Salt Lake City, Utah 84111 801 363-8000

Authorized Agent of

TICOR
TITLE INSURANCE

Policy of Title Insurance

SUBJECT TO THE EXCLUSIONS FROM COVERAGE, THE EXCEPTIONS CONTAINED IN SCHEDULE B AND THE PROVISIONS OF THE CONDITIONS AND STIPULATIONS HEREOF, TICOR TITLE INSURANCE COMPANY (a Stock Company), a California corporation, herein called the Company, insures, as of Date of Policy shown in Schedule A, against loss or damage, not exceeding the amount of insurance stated in Schedule A, and costs, attorneys' fees and expenses which the Company may become obligated to pay hereunder, sustained or incurred by the insured by reason of:

1. Title to the estate or interest described in Schedule A being vested otherwise than as stated therein;
2. Any defect in or lien or encumbrance on such title;
3. Lack of a right of access to and from the land; or
4. Unmarketability of such title.

This policy shall not be valid or binding until countersigned below by a validating signatory of the Company.

Issued By
Western States Title Company
1729 Sidewinder Drive Suite 200
P.O. Box 714
Park City, Utah 84060
(801) 649-8777
AGENT FOR TICOR TITLE INSURANCE

TICOR TITLE INSURANCE COMPANY

By _______________ President

Attest _______________ Secretary

Countersigned:

By _______________
Validating Signatory

OWNERS POLICY

Schedule A

Agent's Order No.: S-9449

Number	Amount of Insurance	Date of Policy	PREMIUM
OWNERS OD 334257	$ 300,000.00	March 19, 1986	985.00
		@ 11:51 a.m.	

1. Name of Insured:

SUMMIT COUNTY

2. The estate or interest in the land described herein and which is covered by this policy is:

FEE SIMPLE

3. The estate or interest referred to herein is at Date of Policy vested in the insured.
4. The land herein described is encumbered by the following mortgage or trust deed, and assignments:

and the mortgage or trust deeds, if any, shown in Schedule B hereof

5. The land referred to in this policy is located in the County of Summit State of Utah and described as follows:

The surface estate only in and to the following:

BEGINNING at a point which falls North 663.21 feet, and West 1,779.79 feet from the Southeast corner of said Section 5, Township 1 South, Range 5 East, Salt Lake Base and Meridian; said Section corner is a mound of stone on a North-South fence line; thence North 67°45'49" East 900.0 feet; thence North 12°48'28" West 827.0 feet; thence North 57°30'44" West 1,140.0 feet; thence South 79°30'16" West 2,148.5 feet; thence South 13°47'58" East 1,945.22 feet; thence North 75°06'51" East 2,028.5 feet to the point of BEGINNING.

TOGETHER WITH an easement for ingress and egress over along and across a sixty foot wide strip of land located in the Southeast quarter of Section 5, Township 1 South, Range 5 East, Salt Lake Base and Meridian; the centerline of which is more fully described as follows:

continued

TO 2085 (8-83)

PARAGRAPH 5

ALTA OWNERS FORM

SCHEDULE A **CONTINUED**

Policy Number ____________________
Loan

Agent's Reference No. S-9449

Policy Number 334257
Owners

BEGINNING at a point which falls North 367 feet, and West 863 feet from the Southeast corner of said Section 5, said point falls on the North right of way line of an existing county road; thence Northwesterly along a curve to the right 136.04 feet, said curve has a central angle of 25°58'58"; thence North 55°52'24" West 242.96 feet to a curve to the right; thence Northwesterly along said curve 212.32 feet; said curve has a central angle of 40°33'; thence North 15°19'24" West 119.18 feet to a curve to the right; thence Northwesterly along said curve 5.46 feet to the boundary line of the Summit County landfill; said curve has a central angle of 1°02'34"; said point falls North 841.38 feet, and West 1343.98 feet from said Southeast corner of said Section 5.

ALTA OWNERS FORM

Schedule B

Policy Number ______________________ Loan

Agent's Reference No. S-9449

Policy Number 334257 Owners

This policy does not insure against loss or damage by reason of the following:

General Exceptions:

(1) Rights or claims of parties in possession not shown by the public records.

(2) Encroachments, overlaps, boundary line disputes, and any other matters which would be disclosed by an accurate survey and inspection of the premises.

(3) Easements or claims of easements not shown by the public records.

(4) Any lien, or right to a lien, for services, labor, or material heretofore or hereafter furnished, imposed by law and not shown by the public records.

Special Exceptions: The mortgage, if any, referred to in Item 4 of Schedule A, and the following exceptions:

(1) Taxes

1. (Affects this and other property)
Taxes for the year 1986, now a lien, not yet due or payable. Taxes for the year 1985, have been paid. (Serial No. NS-32).

2. Easement and Right of Way (width not disclosed) for Electric Transmission and Distribution Facilities as created in favor of UTAH POWER AND LIGHT COMPANY by instrument recorded December 22, 1916 as Entry No. 26948 in Book P of Miscellaneous at Page 71 of the Official Records. Along a center line as follows:

   COMMENCING on the North boundary of Grantor's land at a point 136 feet East of the Northwest corner of Section 5, Township 1 South, Range 5 East, Salt Lake Base and Meridian; thence running South 6°56' East 320 feet to angle point, thence 17°35' East 5060 feet to South boundary of Grantor's land; all contained within the East one-half of Section 5, Township 1 South, Range 5 East, Salt Lake Base and Meridian.

3. Easement and Right of Way (width not disclosed) for Electric Transmission and Distribution Facilities as created in favor of UTAH POWER AND LIGHT COMPANY by instrument recorded March 6, 1955 as Entry No. 85045 in Book 2A of Miscellaneous at Page 228 of the Official Records. Along a center line as follows:

continued

Policy Number
Loan

Policy Number 334257
Owners

Agent's Reference No. S-9449

BEGINNING on the North boundary line of Grantor's land at a point 1625 feet West, more or less, from the East quarter corner of Section 5, Township 1 South, Range 5 East, Salt Lake Base and Meridian; thence South 17°53' East 2330 feet, more or less, thence South 18°12' East 1120 feet, more or less, to the East boundary line of said land and being in the Northwest quarter of the Southeast quarter and the South one-half of the Southeast quarter of said Section 5.

4. A Right of Way and easement 30 feet in width for gas distribution facilities, as created in favor of MOUNTAIN FUEL SUPPLY COMPANY by instrument recorded July 13, 1970 as Entry No. 111391 in Book M26 at Page 663 of the Official Records, through and across said property along a center line described as follows:

BEGINNING at a point 676.43 feet North and 1.82 feet East from the Southeast corner of said Section 5, said point being on the East line of Grantor's property, thence South 59°55'53" West 266.20 feet, thence South 70°39'15" West 542.30 feet, thence South 73°44'15" West 377.36 feet, thence South 60°39'15" West 201.80 feet, thence South 40°26'15" West 193 feet, more or less, to the South line of Grantor's property.

5. Easement and Right of Way (width not disclosed) for Electric Transmission and Distribution Facilities as created in favor of UTAH POWER AND LIGHT COMPANY by instrument recorded October 6, 1970 as Entry No. 111881 in Book M28 at Page 227 of the Official Records. Along a center line as follows:

BEGINNING in an existing line on the Grantor's land at a point 510 feet North and 1160 feet West, more or less, from the Southeast corner of Section 5, Township1 South, Range 5 East, Salt Lake Base and Meridian; thence South 84°22' East 1162 feet to the East boundary fence of said land and being in the Southeast quarter of the Southeast quarter of said Section 5.

6. Reservations contained in that certain Patent recorded April 2, 1902 as Entry No. 10623 in Book G at Page 512 of the Official Records, said reservations being set forth as follows:

Yet excluding and excepting from the tranfer by these presents "All mineral lands: should any such be found to exist in the tracts described in the foregoing but this exclusion and exception according to the terms of the State "Shall not be construed to include coal and iron land."

7. Reservations contained in that certain Deed executed by the UNION PACIFIC RAILROAD COMPANY and recorded February 8, 1910 as Entry No. 19754 in Book J at Page 65 of the Official Records, said reservations being set forth as follows:

continued

Policy Number ______________________
Loan

Policy Number 334257
Owners

Agent's Reference No. S-9449

FIRST: All coal and other minerals within or underlying said lands.
SECOND: The exclusive right to prospect in and upon said land for coal and other minerals therein. or which may be supposed to be therein, and to mine for and remove, from said land, all coal and other minerals which may be found thereon by anyone.
THIRD: The right of ingress, egress and regress upon said land to prospect for, mine and remove any and all such coal or other minerals, and the right to use so much of said land as may be convenient or necessary for the right of way to and from such prospect places, mines and for roads and approaches thereto or for removal therefrom of coal, minerals, machinery or other materials.
FOURTH: The right of said UNION PACIFIC RAILROAD COMPANY to maintain and operate its railroad in its present form of construction, and to make any change in the form of construction or method of operation of said railroad.

9. Terms and conditions contained in that certain Warranty Deed executed March 19, 1986 by UTELITE CORPORATION, in favor of SUMMIT COUNTY, recorded March 19, 1986 as Entry No. 247813 in Book 377 at Page 10 of the Official Records, reference to which is hereby made for the particulars.

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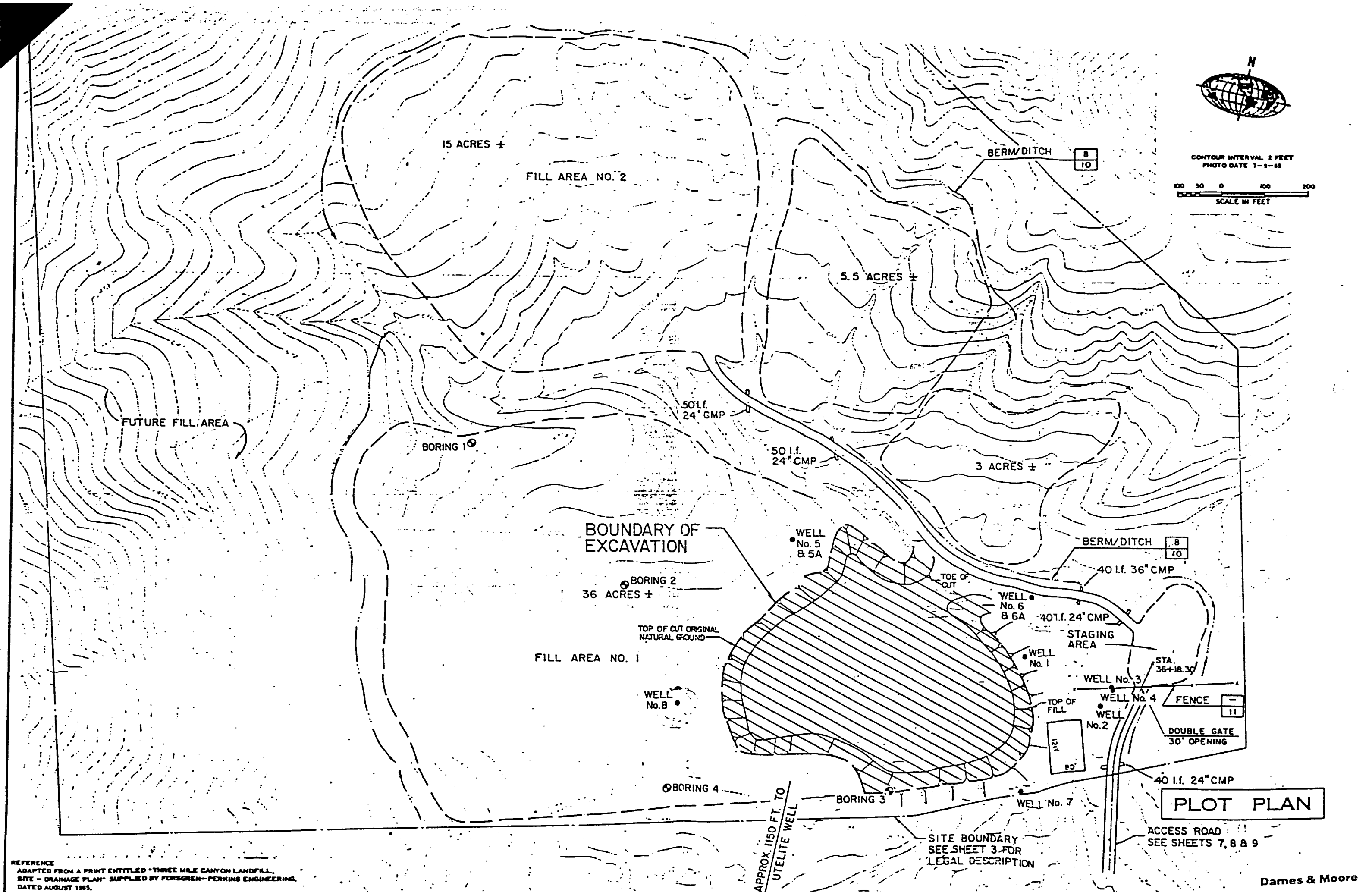
INITIAL BERM LAYOUT



REFERENCE
ADAPTED FROM A PRINT ENTITLED "THREE MILE CANYON LANDFILL, SITE - DRAINAGE PLAN" SUPPLIED BY FORSGREN-PERKINS ENGINEERING, DATED AUGUST 1985.

Dames & Moore

PLATE 1

APPENDIX B

SAMPLING PLAN AND FORMS

GROUNDWATER MONITORING PLAN

AT

THREE MILE CANYON LANDFILL
SUMMIT COUNTY, UTAH

Prepared for

SUMMIT COUNTY
P.O. Box 128
Coalville, Utah 84017

Prepared By

ATC Associates, Inc
2681 East Parleys Way
Salt Lake City, Utah 84109

July 30, 2003

GROUNDGWATER MONITORING PLAN

AT

THREE MILE CANYON LANDFILL
SUMMIT COUNTY, UTAH

JULY 2003

GROUNDWATER MONITORING PLAN

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1. INTRODUCTION

1.1 GENERAL

Summit County owns and operates a Class I and Class IV Municipal Solid Waste Landfill at Three Mile Canyon in Summit County, Utah. The site is located about four miles south of Wanship and a half-mile southwest of Rockport Reservoir, on the north site of Three Mile Canyon as shown on Figure 1. The Three Mile Canyon landfill became operational in 1986. The permitted landfill cell occupies approximately 23.7 acres.

Summit County has requested that ATC Associates (ATC) develop a Groundwater Monitoring Plan (Plan) for the Three Mile Canyon Canyon Landfill to satisfy requirements of Utah Administrative Code (UAC) R315-308-2.

The plan provides specific details on procedures and methods that will be used in the field and laboratory to meet project objectives for data quality of all groundwater monitoring required under R315-308-2. Specific statistical methods to be used in determining whether a significant change has occurred as compared to background will be propose upon establishment of background concentrations.

1.2 HYDROGEOLOGY

The soils at the site consist primarily of alluvial and colluvial low permeability silty Clay with thickness ranging from 5 to 20 feet. Bedrock underlying the soils consists of fine-grained low permeability siltstone. The siltstone beds Strike northeast, and dip to the northwest at angles ranging from 25 to 75 degrees.

Groundwater occurs in three main water bearing zones at the site: a shallow perched water zone and at least two deeper aquifers. An apparent perched water-bearing zone was detected in several exploratory borings at depths ranging from 19 to 25 feet. This water zone occurs in the upper sections of bedrock underlying the site and is derived principally form snowmelt and storm water runoff. The direction of flow of the perched aquifer follows the topography, flowing southeast into the colluvail-alluvil soils of Three-Mile Canyon.

The main occurrence of groundwater, as encountered in the monitor wells, is within the siltstone bedrock within local fracture zones. Most of the site wells were screened within the uppermost fractured zone, which exhibited moisture during drilling, with the exception of MW4, which was completed in a lower fractured zone. Figure 2 presents the locations of all monitor wells, which have been completed at the site, including those, which did not encounter water. Nine groundwater monitor wells, identified as MW1 through MW9 were drilled and installed at the site. The wells were drilled through the surface soils and into the soft underlying weathered bedrock using a truck-mounted drill rig with hollow stem augers. Once bedrock was encountered rotary drilling methods with compressed air were utilized. MW9 was drilled with an AP-1000 truck-mounted Becker Hammer drill rig using 9-inch dual wall pipe with reverse air circulation through the surface soils and into the soft underlying bedrock. A rotary drill rig using compressed air was used in the bedrock.

Wells MW3, MW4, MW7, MW8, and MW9 have been monitored at the site. The apparent groundwater gradient is to the east, generally following the topography. The groundwater contours were estimated from water levels measured in wells MW3, MW7, and MW9 in November 1996. The aquifer flows toward the Weber River Valley and associate alluvial deposits to the east. However, there is evidence that although the area groundwater gradients flow toward Rockport Reservoir, The reservoir is locally recharging the groundwater system. The groundwater gradient across the site is approximately 0.1 ft/ft. Figure 3, the piezometeric surface in the majority of the sites wells is above the screen interval in the bedrock fracture zone.

Also indicated on Figure 3 is the apparent dip of the siltstone beds. The actual dip of the beds is to the northwest. The differing siltstone layers in which the wells are completed may contribute to the different water chemistry. The principal sources of recharge into the water bearing zones are likely to occur by infiltration into exposed rock outcrops around the basin perimeter.

Groundwater at the site has been routinely analyzed since landfilling operations began. Four wells, which were originally sampled, were MW3, MW4, MW7, and MW8. In 1994, well MW9 replace MW8 as the upgradient monitoring point. From 1994 through the 1996 sample events, four wells were monitored at the site, including three down gradient wells (MW3, MW4 and MW7) and an up gradient well (MW9). Sampling of MW4 was discontinued in 1997, based on evidence presented herein that it is screened is a separate water bearing zone than MW3. The solid waste regulations state in R315-308-2(1) that the uppermost aquifer and all hydraulically connected aquifers below the facility is to be monitored. Wells MW3 and MW4 are completed within 7.5 feet of each other, yet their water levels are different by as much as 16 to 21 feet. MW3 was screened from elevation 6127 to 6137 feet above mean sea level. MW4 was screened from 6086 to 6106 feet above mean sea level. Based on the different water levels within MW3 and MW4, there does not appear to be a hydraulic connection between the water bearing zones they represent. The Division of Solid and Hazardous Waste (DSHW) concurred and MW4 is no longer a compliance monitor well.

2. GROUNDWATER MONITORING NETWORK

2.1 MONITOR WELL NETWORK

The compliance monitor well network at the Three Mile Canyon Land fill consists of two (2) downgradient monitor wells identified as MW3 and MW7, and one (1) upgradient monitor well identified as MW9. Locations of the wells are shown on Figure 2. The original upgradient well completed at the site was MW8, which was destroyed during landfill operations and was replaced by MW9 in 1994. Completion details and survey information for the compliance monitor wells are summarized in Tables 1 and 2 . Details of all wells at the site are included in Attachment 1.

Table 1

MONITOR WELL COMPLETION DETAILS THREE MILE CANYON LANDFILL						
Well ID	Location	Elevation Above Mean Sea Level (feet)				
		Sand Pack		Screen		Groundwater (Nov 1996)
		Top	Bottom	Top	Bottom	
MW3	Downgradient	6140.09	6128.09	6137.09	6127.59	6137.07
MW7	Downgradient	6123.40	6095.90	6122.90	6096.40	6146.86
MW9	Upgradient	6217.50	6185.50	6211.20	6190.50	6298.10

Table 2

SUMMARY OF MONITOR WELL LOCATONS AND ELEVATIONS THREE MILE CANYON LANDFILL				
Well ID	Northing (feet)	Easting (feet)	Elevation Top of PVC (feet)	Elevation Ground Surface (feet)
MW3	11152.76	13967.76	6187.56	6184.09
MW7	10880.67	13803.92	6191.04	6198.40
MW9	11256.70	12213.71	6327.80	6325.48

2.2 WELL CONSTRUCTION AND COMPLETION

Installation of all monitor wells was performed according to procedures required by the UDSHW. Groundwater monitor wells were installed using 2-inch diameter, schedule 40, flush threaded polyvinyl chloride (PVC) well casing and screen (0.010-inch slot). A sand pack consisting of 16-40 Colorado silica sand was placed in the annular opening, from the bottom of the bore hole to a minimum of two feet above the top of the well screen. A minimum of a two-foot thick seal, consisting o bentonite pellets, was placed on top of the sand pack and hydrated. Portland Type I/II neat cement grout with 5% bentonite was placed from the bentonite seal to the ground surface. All groundwater monitor wells were complete above ground with a locking well cover set in concrete. Well completion details and boring logs for all monitor wells are provided in Attachment 1.

All monitor wells were developed for groundwater sampling by surging and bailing sediment-laden water until the groundwater was relatively clear.

3. SAMPLING OPERATIONS AND PROCEDURE

The following subsections detail specific sampling techniques and methodology to be used during all groundwater monitoring to provide consistency between sampling events. Monitoring well networks are required to be sampled semiannually according to R315-308-2 (4)(b) after background levels are established. If there is significant increase over in any parameter or constituent at any monitoring well at the compliance point assessment monitor may be initiated according to R315-308-2 (11).

3.1 GROUNDWATER SAMPLING PROCEDURES

3.1.1 General

The sampling procedures consist of obtaining groundwater samples from the compliance monitor wells, identified in Section 2.1, utilizing a submersible pump system or bailer. Summit County may elect to replace the submersible pump system with dedicated bladder pumps and utilize micro-purging techniques; the UDSHW will be notified of any pump replacements. Coordination for conducting the sampling events will be established prior to sampling. Sampling equipment will be prepared and properly calibrated prior to the sampling event. All information obtained in the field shall be recorded on a Groundwater Monitoring Data Sheet, similar to the one presented in Attachment 2.

The groundwater monitor wells at the Three Mile Canyon Landfill will be sampled in the order of upgradient well first, then proceeding to the downgradient wells. Upon arrival at a well, the condition of each of the monitor wells will be observed and noted on the field data sheet, i.e., that the wells are secured with a lock, that the apron is intact, and the outer casing is in good repair. Any required repairs will be noted on the field sampling sheets.

The monitor wells shall be sampled using currently accepted and approved technology or approved equivalent techniques. Competent personnel who are familiar with proper sampling techniques and health and safety procedures will perform groundwater sampling. Groundwater samplers should also be knowledgeable in techniques of well purging, sample collection and preservation, decontamination, and quality assurance/quality control (QA/QC). The sampler will wear a new pair of nitrile gloves at each well for handling sampling equipment and containers.

3.1.2 Water Level Measurements

A location on the protective casing of each well will be marked with paint or cold chisel to indicate the point on the protective will casing from which depth to groundwater will be measured. The elevations of the specific location from which depth to groundwater is measured will have been surveyed by a registered engineer or licensed surveyor and reported to the nearest 0.01 foot. Prior to purging and sampling, water level readings must be obtained using a conductivity-based water level indicator or equivalent instrument capable of obtaining measurements to the nearest 0.01 feet. The probe will be cleansed between each well by washing with a non-phosphate detergent and triple rinsing with deionized or distilled water. The probe is then lowered until the level indicator (alarm) sounds or the light turns on. The measuring tape is read from the survey measuring point to the nearest 0.01 foot. The measurement will be repeated until two consecutive reading agree to the nearest 0.01foot, and the value is recorded on the Groundwater Monitoring Data Sheet. The water level should also be taken post sampling just prior to turning off the pump to determine if pumping has created excessive drawdown and whether adjustment of pumping rates are necessary.

3.1.3 Well Purging

Prior to sampling, the wells will be purged, utilizing a submersible pump or bladder pump, to ensure the groundwater sample is representative of formation water, the submersible pump, should be lowered to the depth specified in Table 3. If Summit County elects to replace the existing submersible pump with dedicated bladder pumps, the bladder pump intakes will be positioned at a distance approximately equal to 1/3 of the saturated screened length from the bottom of the screen. The pump controller will be attached to the pump air supply line, and the oil-less compressor should be located downwind and away from the well and the air supply line attached to the pump controller. The groundwater, which is being discharged from the well, should be monitored for specific conductance, temperature and pH. All three parameters will be recorded on the filed data sheets 3-minute intervals. The groundwater sample will be collected after all three parameters have stabilized (two consecutive measurements within 10%), indicating adequate purging. Table 3 indicates the minimum volume required to be purged prior to sampling.

Table 3

MONITOR WELL PUMP DEPTH AND MINIMUM PURGE VOLUMES
THREE MILE CANYON LANDFILL

Well ID	Ground Surface Elevation (feet)	Pump Depth (feet)	Min. Purge Volume Liters	Min. Purge Volume Gallons
MW-3	3184.1	53	12.0	3.2
MW-7	3189.4	82	18.0	4.8
MW-9	6325.5	125	22.0	5.8

Purge water will be disposed of on the ground surface no closer than 20 feet from any well. If any well produces water with constituents exceeding primary drinking water quality standards (determined from the most recent sampling event) all purge water from that well will be containerized and disposed of appropriately. The potential for contamination or cross-contamination of the samples will be minimized by decontaminating the pump and tubing between wells (see Section 3.1.6, Decontamination). Care will be taken to place gasoline powered generator or compressor so that exhaust gases will not contaminate samples.

3.1.4 Field Measurements

Field parameters, including specific conductance, temperature, and pH, will be recorded on field data sheets. After the parameter stabilize the groundwater samples will be collected. Monitoring probes will not be placed into the sample containers, which will be submitted to the laboratory for analysis. After the water in the beaker is rested for field parameters it will be disposed of. After samples have been collected for laboratory analysis, another beaker of water is to be retested for pH, temperature, and specific conductance as a measure of purging efficiency and as a check of the stability of the water samples over time. These readings along with date, time, well ID, and purge volume will be recorded on the Groundwater Monitoring Data Sheet.

The instrument(s) used to perform field measurements will be calibrated in accordance with manufacturer's recommendations at the beginning and end of each day, at a minimum.

3.1.5 Sample Collection and Preservation

After parameters have stabilized, groundwater will be collected. The groundwater sampler will wear a new pair of disposable nitrile gloves to handle sampling equipment and sample containers at each well. The groundwater samples will be collected directly from the pump discharge line into laboratory supplied bottles without filtering. Table 4 summarizes the types of containers and associated preservatives that will be used for the sample storage and transport. Any required preservatives will be added to the containers in advance by the laboratory.

3.1.3 Well Purging

Permanent low flow pumps shall be installed into monitoring wells during 2004 that will provide for a dedicated groundwater monitoring program. These pumps shall be used in the quarterly water quality monitoring program.

3.14 Field Measurements

Field parameters, including specific conductance, temperature, pH, will be recorded on field data sheets. After the parameters stabilize the ground water samples will be collected. Monitoring probes will not be placed into the sampling containers, which will be submitted to the laboratory for analysis. After the water in the beaker is rested for field parameters it will be disposed of. After samples have been collected for laboratory analysis, another beaker of water is to be retested for pH, temperature and specific conductance as a measure of purging efficiency and as a check on the stability of the water samples over time. These readings, along with date, time and well ID and purge volume will be recorded on the Groundwater Monitoring Data Sheet.

The instruments used to perform field measures will be calibrated in accordance with the manufacturer's recommendations at the beginning and end of each day , as a minimum.

3.1.4 Sample Collection and Preservation

After parameters have stabilized, the groundwater will be collected. The groundwater sampler will wear a new pair of disposable nitrile gloves to handle the sampling equipment and sample containers at each well. The groundwater samples will be collected directly from the pump discharge into laboratory supplied bottles without filtering. Table 4 summarizes the types of containers and associated preservatives that will be used for the sample storage and transport. Any required preservatives will be added to the containers in advance by the laboratory.

Table 4

REQUIRED SAMPLE CONTAINERS AND PRESERVATIVES			
Parameter	Sample Container	Preservative	Holding Time
Volatile Organic Compounds (VOC's)	Four (4) 40 ml glass vials with Teflon-lined lid	HC1, 48C	14 days
TOC and NH3	One (1) 16 ounce HDPE	H2SO4, 48C	28 days
Inorganics	One (1) ½ gallon HDPE	48 C	28 days
Metals	One (1) 16 ounce HDPE	HNO3, 48C	6 months

Sample containers will be filled in the following order to minimize degradation of sensitive parameters

1. VOCs
2. TOC and NH3
3. Inorganics
4. Metals

Care should be taken to maintain the lids on the containers until the time to fill the container with the sample. Once filled, the containers should be immediately capped to minimize contact with dust and ambient air, and to avoid volatilization of the sample. The VOC vials should be completely filled with zero headspace. Samples are to be labeled and immediately stored on ice in a cooler until delivered under chain of custody to the laboratory for analysis.

Field blank and duplicate samples will be prepared as part of the QA/QC Plan outlined in Section 5.

3.1.6 Decontamination

The submersible pump and tubing used to purge the wells is to be decontaminated between wells. The pump shall be decontaminated using a non-phosphate detergent and water. The detergent mixture should be pumped through the pump and tubing until the entire length of discharge tubing is filled with the solution. Distilled (or deionized) water should then be pumped through the pump and tubing until the discharge water is free of suds.

The water level indicator, field parameter instrument(s) and any other sampling equipment should be decontaminated between wells with a non-phosphate detergent, then triple rinsed with distilled (or deionized) water.

3.1.7 Sample Handling

Once collected, each sample will be immediately labeled, recorded on the Groundwater Monitoring Data Sheet, and placed in a sample cooler with ice for transport to the laboratory. Samples will be hand-delivered to a State of Utah certified laboratory within 24 hours of collection. All samples will be delivered to the laboratory within a sufficient time frame to insure that project hold times will not be exceeded by the laboratory for the specified parameters. Each sample will be accompanied by a chain-of-custody form filled out at the time of sample collection.

3.1.8 Documentation

An essential part of the sample collection activity is the documentation of the site measurements and ensuring the integrity of the sample from collection to data reporting. The following records and actions will be taken.

1. Sample Labels. All samples will be labeled with the sample identification, name of the sampler, date and time of collection, and type of preservative (if required). The sample label will be filled out completely and attached to each sample bottle or container at the time of collection.

2. Chain-of- Custody. A chain-of-custody from will accompany all samples from the time of collection to completion of laboratory analysis. The chain-of-custody record will establish the documentation necessary to trace sample possession from the time of collection through receipt by the analytical laboratory. The original form will accompany the samples to the laboratory and copies will be placed into the project file. Original forms will be returned with the analytical results from the laboratory.

3. Sampling Record. Pertinent field measurements and observations noted during sampling will be recorded by the field technician on the Groundwater Monitoring Data Sheet (one for each well) and in his field notes.

Examples of the Sample Labels, Chain-of-Custody, and Groundwater Monitoring Data Sheet forms are included in Attachment 2.

3.2 SAMPLE IDENTIFICATION

Each sample will be given a unique identification consisting of the monitor well ID. For example, groundwater sampled from monitor well MW3 will be labeled "MW3". The field duplicate sample from MW3 will be labeled "MW13" and field notes will verify from which monitor well it was obtained.

4. SAMPLE ANALYSIS

4.1 ASSESSENT MONITORING ANALYTES

All laboratory chemical analyses will be conducted according to EPA standards and procedures as set forth in EPA SW-846. Samples will be analyzed for constituents listed in Appendix II in 40 CFR, Part 258, 2001 ed., using the recommended EPA Method. The laboratory will follow the procedures as described and identified and/or adjust for potential interferences. Laboratory personnel will provide information on the precision and accuracy or the testing, and include results of QA/QC laboratory samples.

The Rule states in R315-308-2(4)(d) that analysis shall be performed for the required constituents on unfiltered samples. Samples will be collected without filtering in the files and the laboratory will be instructed to analyze unfiltered samples.

5. QUALITY ASSURANCE/QUALITY CONTROL

A detailed quality assurance/quality control (QA/QC) Plan has been developed for sampling and analysis of the groundwater. The objective of the monitoring Plan is to obtain high quality, consistent data that may be used to track long-term variations and trends in the groundwater at the site. Specific QA/QC procedures have been developed to accomplish this objective, as well as to identify sampling or laboratory analytical errors with may occur. A Quality Assurance Officer (QAO) will be assigned by Summit County to review the data for completeness, accuracy and precision. The QAO is generally affiliated with the organization performing the sampling.

5.1 ACCURACY

Accuracy is the nearness of a measurement or set of measurements to the true value. It is evaluated by means of a matrix spike sample analysis. A known quantity of analyte is added to sample matrix. The spike concentrations added are 1.0 ppm for metals and 20 ppb for volatile organic compounds. A sample identified as a field blank may not be used for the analysis. Spike recovery is calculated using the following equation:

$$\% R = \frac{(SSR - SR)}{SA} \times 100$$

Where:	R	=	Spike Recovery
	SSR	=	Spiked Sample Result
	SR	=	Sample Result
	SA	=	Spike Added

Target recoveries of 80% to 120% are acceptable for most analytes (70% to 130% for arsenic, lead, selenium, and thallium). Some organic constituents have acceptable ranges of 60% to about 140%. IF the spike recovery falls outside the specified range, the data will be qualified as "acceptable", "estimated", or "rejected".

5.2 PRECISION

Precision is an assessment of the agreement between a set of replicate measurements without assumption or knowledge of the true value. Precision is evaluated by means of duplicate sample analysis.

Precision is determined using the following formula:

$$RPD = \frac{(S - D)}{(S + D)/2} \times 100$$

Where	RPD	=	Relative Percent Difference
	S	=	*Sample Result*
	D	=	Duplicate Sample Result

Duplicate samples will have a control limit of +/- 20% for the Relative Percent Difference (RPD) for sample values greater than 5 times the laboratory detection limit (LDL). If the sample values are less than 5 times the laboratory detection limit, a control limit of +/- the LDL shall be used.

If field duplicate analysis results for a particular Analyte falls outside the control windows of +/-20% or +/- LDL, which ever is appropriate, the results for that Analyte in all other samples associated with that laboratory set may be flagged as estimated.

5.3 QA/QC SAMPLES

5.3.1 Field Duplicates

A blind duplicate sample will be collected and submitted for analysis during each sampling round to assess data precision. It will be labeled in such a way so its identity as a duplicate sample will not be known by the analytical laboratory.

5.3.2 Laboratory QA/QC Samples

The laboratory required to provide results for two types of QA/QC samples: method blanks and matrix spike/matrix spike duplicates. Matrix spike/matrix spike duplicates are required for each metal and inorganic analyte and for a representative number of organic analytes.

Method blanks provide verification that an analyte has not been introduced into the sample during laboratory handling and analysis. Matrix spike/matrix spike duplicates provide an indication of the laboratory accuracy and precision.

5.3.3 Trip and Field Blanks

A trip blank and a field blank will be prepared and sealed by the analytical laboratory prior to the sampling event. Both blanks are intended to be aqueous solutions that are as free of analytes as possible.

The trip blank will be transported to the sampling site and back to the laboratory without being opened, accompanying the sample bottles the entire time. It serves as a check on sample contamination originating from sample transport, shipping, and from site conditions.

The trip blank container is opened in the files for the same amount of time as the collection of one of the groundwater samples. It is then sealed and is transported with the other samples to the laboratory. It serves as a check on environmental contamination.

The trip blank and field blank will be analyzed if deemed necessary to check for contamination originating from a source other than the site groundwater. If, for example an unexpected contaminant is encountered in a groundwater sample from the site, one or both field blanks may be analyzed to rule out contamination originating from another source. The blanks would be analyzed for the same parameter listed in Table 5.

5.4 REPORTING LIMITS

The laboratory is required to meet the established reporting limits given in Table 5 for each analyte. The reporting limits are designed to be below the drinking water quality criteria. If the laboratory is unable to meet the required limit for an analyte or group of analytes due to characteristics of the sample, the laboratory is required to contact Summit County or their sampling representatives immediately. If changes in the sampling protocol or established reporting limit are necessary, the UDSHW will be immediately notified.

5.5 LABORATORY INTERNAL QUALITY CONTROL

5.5.1 Calibration Procedures and Frequency

Laboratories subcontracted to perform chemical analyses will be certified by the State of Utah for environmental analysis. As such, they will follow the calibration procedures according to and at the minimum frequency required by the State.

5.5.2 Internal Quality Control Checks

The laboratory will conduct internal quality control check according to its own QA Plan that is a part of Sate certification requirements. The laboratory will summarize the results of these quality control checks and submit them with the analytical results.

The quality control check and the laboratory performance and system audits will include:

1. Method Blanks
2. Laboratory control samples
3. Calibration check samples
4. Replicate samples
5. Matrix-spiked samples
6. "Blind" quality control samples
7. Control charts
8. Surrogate samples

9. Zero and span gases
10. Reagent quality control checks

5.5.3 Preventive Maintenance Procedures and Schedules

Preventive maintenance procedures and schedules will be followed according to specifications outlined in the requirements for laboratory certification by the State.

5.5.4 Corrective Action for Laboratory Problems

Corrective action will be initiated if results of analysis are not within the precision, accuracy and completeness specified in the groundwater monitoring Plan. Sufficient quantities of sample will be retained by the lab so that parameters could be reanalyzed if results are unacceptable and hold times have not been exceeded. In the event that hold times are exceeded, the QAO will decide if a resampling and reanalysis is required.

6. DATA ANALYSIS PLAN

6.1 DATA VALIDATION

When the laboratory data is received, it will be reviewed by the QAO to assess data validity. The data package will be checked to insure that:

- Sample I.D. s match chain-of-custody and field notes, and can be matched to sample location, date, and time.
- Samples were analyzed by requested methods.
- Samples were analyzed within holding times.
- Analysis reporting limits are acceptable.
- Laboratory method blank results are included and acceptable.
- Laboratory matrix spike/matrix spike duplicate results for representative analytes are included and acceptable.
- Field duplicate sample results are included and acceptable.

If potential problems or discrepancies are encountered, the laboratory will be notified and requested to help resolve the question. If the cause of the problem cannot be located, the affected data will be qualified of the affected well will be re-sampled, depending on the severity of the problem. The QAO will use professional judgment to assign qualifiers to data that do not meet the required data quality objectives. If the data appears usable and can be combined with the historical data with no reservations, then no qualifier will be attached. The reasoning will be detailed in the report prepared for the sampling event.

If the data appears to accurately represent the presence or absence of an analyte, but the qualifications of the analyte is in question, the a "J" will be assigned to the reported concentration to indicate it is an estimated quantity. An example of this might be a case where arsenic is reported in the sample, but arsenic recoveries in the matrix spike/matrix spike duplicate are very low (such as 50%). The QAO may feel that the reported arsenic value is useful information even if the result is probably too low. In this case, a "J" would appear next to the reported result in subsequent tabulations of the data for that well.

If the data for an analyte appear compromised to the point where the reported result is not useful (such as the appearance of methylene chloride in the method blank and in a sample at similar concentrations), the data will receive an "R" qualifier indicating it is rejected. The reported result will continue to be shown in subsequent tabulations, but the "R" qualifier will flag the user not to include the result in statistical compilations, etc.

In all cases where data receive qualifiers, an explanation of the QAO's judgement will be given in the report of the sampling round where the qualified data are first reported.

6.2 DATA ANALYSIS

The data will be analyzed by:

- Looking for the presence of non-naturally occurring compounds in the sample (such as volatile organic compounds), and
- Plotting the concentrations of naturally occurring constituents (metals and minerals) in each well in control charts for that well.

If non-naturally occurring compounds are reported by the laboratory, the validity of the result(s) will be assessed by reviewing method blank results, raw laboratory data, the compound's potential status as a common laboratory contaminant, and the reported concentration relative to the method detection limit. If the positive results appear potentially valid, the affected well will be re-sampled to verify the result.

The relative concentrations of naturally-occurring constituents will be analyzed to assess whether the water is impacted. Once the background levels are established for the site wells, an appropriate statistical method will be selected to analyze the sampling data from each succeeding sample event. The statistical method will satisfy the requirements of R315-308-2(7).

The hydrogeology at the site is complex, and it is unclear whether the wells are truly connected within the same fracture zones in the siltstone bedrock. Because of this, inter-well comparisons of water quality data between upgradient and downgradient wells may be complicated by natural variations within the wells. Intra-well comparisons may be more useful in determining groundwater quality at the site.

6.3 DATA REPORTING

Quarterly monitoring reports will be prepared within one month of the sampling date, which will include the following information:

- Description of sampling activities
- Discussion of data validity
- Discussion of laboratory QA/QC
- Presentation of water elevation measurements, groundwater direction and flow rate
- Presentation of field and laboratory data

7. SITE SAFETY

In order to satisfy the requirement listed in R315-308-2(3)(g), the following health and safety procedures will be followed to ensure employee health and safety during well installation and monitoring at the site.

7.1 DRILLING

If drilling is required at site, it will be performed by drillers and geologists/engineering personnel who have had 40 hour HAZWOPER training in accordance with OSHA requirements set forth in 29 CFR 1910. Workers should become familiar with the site and potential hazards before initiating the work, by talking with the landfill manager. If is recommended that workers utilize Level D personal protection consisting of:

- Coveralls and long sleeve shirt
- Safety boots or shoes
- Safety glasses or goggles
- Hard hat
- Work gloves
- Hearing Protection

7.2 MONITORING

Groundwater monitoring shall be performed by personnel who have had 40 hour HAZWOPER training in accordance with OSHA requirements set forth in 29 CFR 1910. Workers should become familiar with the site and potential hazards before the work is performed, by talking with the landfill manager. It is recommended that workers utilize Level D personal protection consisting of:

- Coveralls and long sleeve shirt
- Safety boots or shoes
- Safety glasses or goggles
- Nitrile gloves.

8. REFERENCES

Bingham Environmental, Inc., 1995, Class I Municipal Solid Waste Landfill Application, Summit County, Utah.

Bingham Environmental, Inc., 1996, Addendum #1, Class I Municipal Solid Waste Landfill Application, Summit County, Utah.

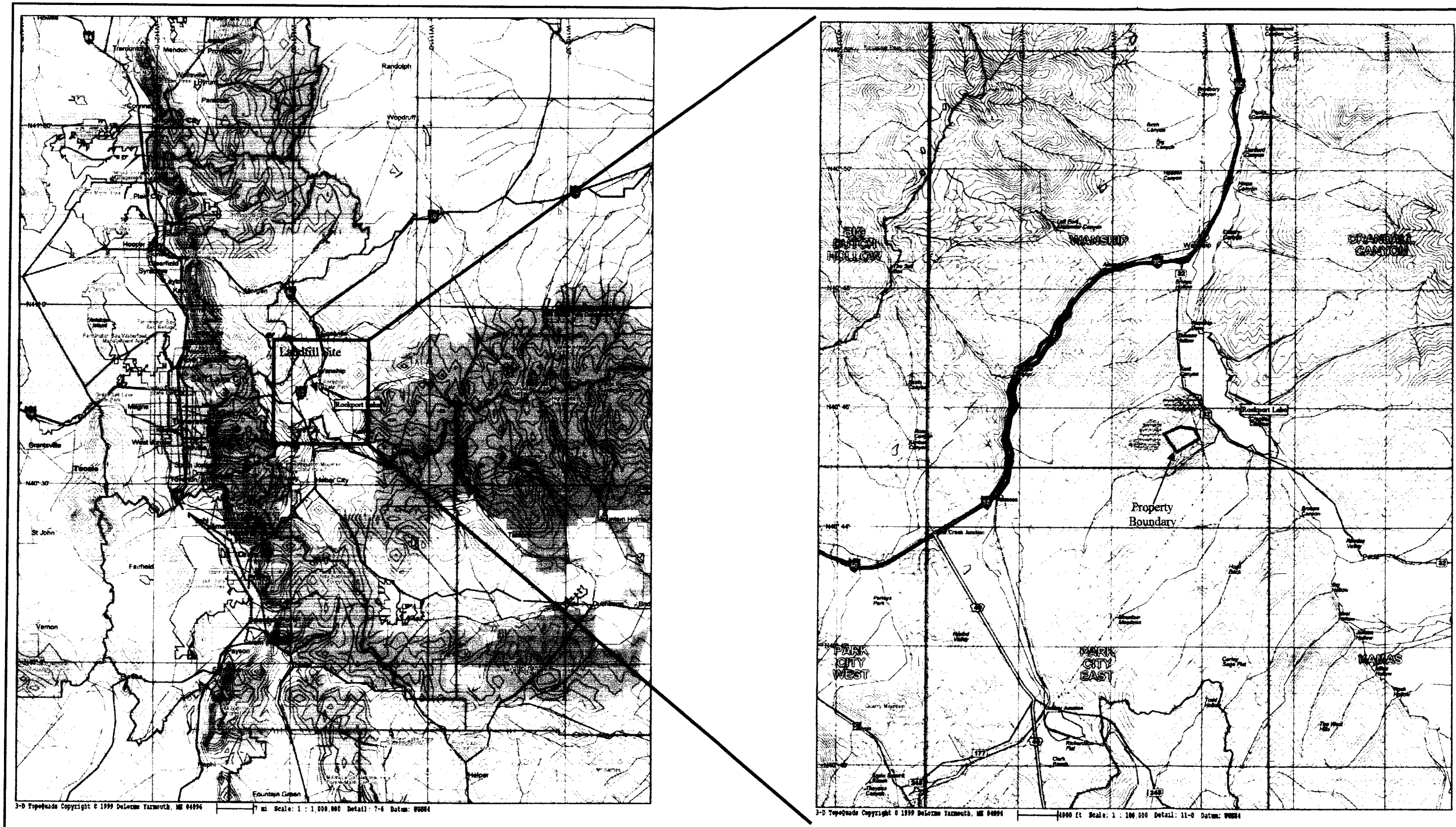
Bingham Environmental, Inc., 1997, Addendum #2, Class I Municipal Solid Waste Landfill Application, Thee Mile Canyon, Summit County, Utah.

Dames & Moore, 1987, Report: Drilling, Field Testing and Installation for an Upgradient Observation Well, Summit County Landfill Located Just North of Three Mile Canyon, South of Wanship, Utah, for Summit County.

Forsgren-Perkins Engineering, p.a., 1985, Three-Mile Canyon Landfill Site, Summit County, Utah.

EPA, 1983, Methods for Chemical Analysis of Water and Wastes: EPA 600-4-79-020, Revised March 1983.

EPA, 1986, Test Methods for Evaluating Solid Waste, EPA SW-846, Third, Edition



LOCATION MAP

THREE MILE CANYON CLASS I & IV LANDFILL

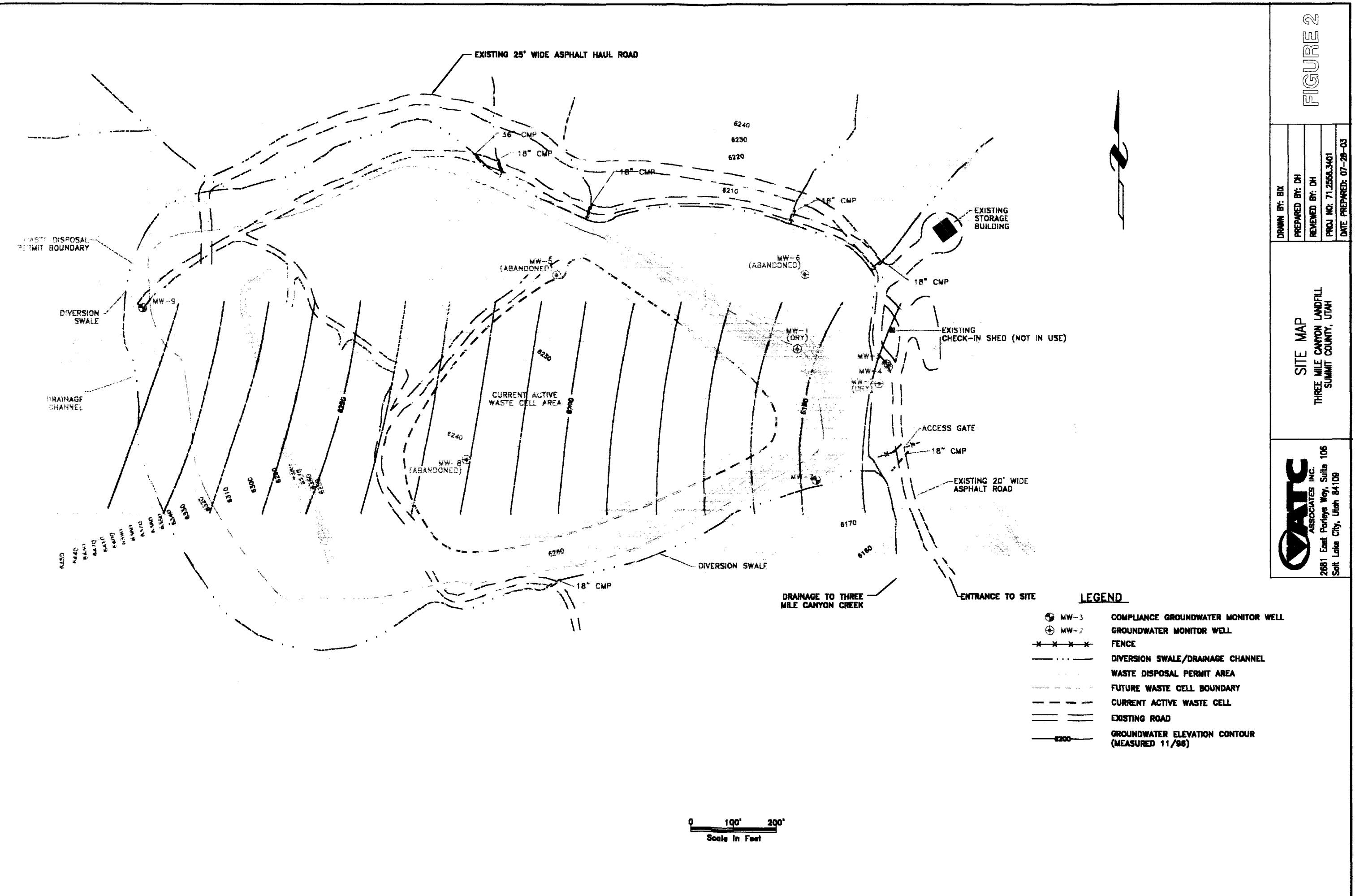
PROJECT NO: 71.25561.3401

SOURCE: Delorme 3-D TopoQuads, 1999 Edition

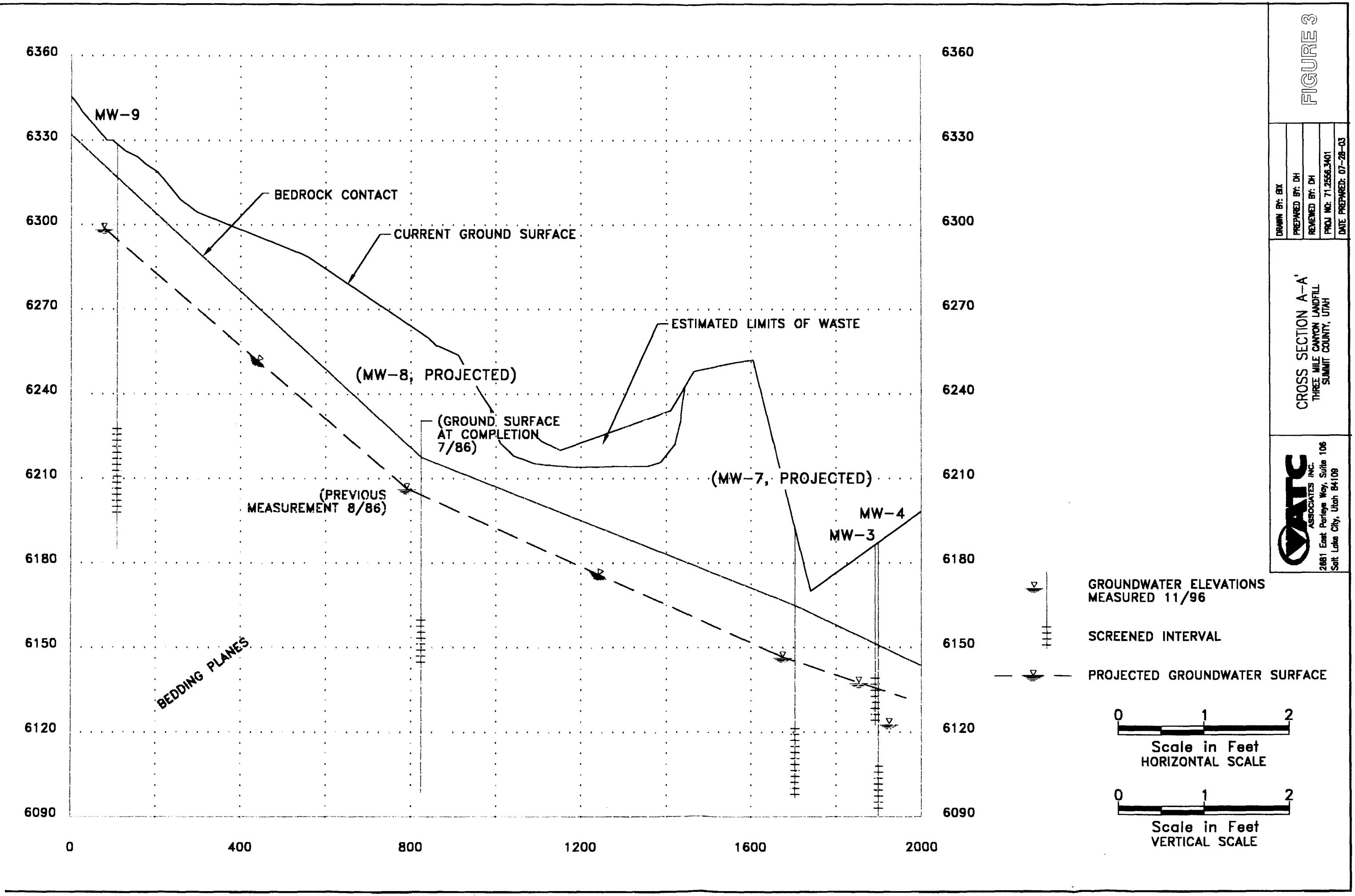
FIGURE 1

ATC Associates Inc.
2681 Parleys Way, Suite 106
Salt Lake City, Utah 84109
(801) 412-0003

ATC ASSOCIATES INC.



EXISTING 25' WIDE ASPHALT HAUL ROAD
36" CMP
18" CMP
18" CMP
18" CMP
18" CMP
18" CMP
18" CMP
18" CMP
EXISTING STORAGE BUILDING
WASTE DISPOSAL PERMIT BOUNDARY
DIVERSION SWALE
DRAINAGE CHANNEL
MW-5 (ABANDONED)
MW-6 (ABANDONED)
MW-9
MW-1 (DRY)
MW-8 (ABANDONED)
MW-3
MW-4
CURRENT ACTIVE WASTE CELL AREA
EXISTING CHECK-IN SHED (NOT IN USE)
ACCESS GATE
EXISTING 20' WIDE ASPHALT ROAD
DIVERSION SWALE
DRAINAGE TO THREE MILE CANYON CREEK
ENTRANCE TO SITE
6240
6230
6220
6210
6250
6240
6200
6180
6170
6160
6260
6280
6290
6300
6310
6320
6330
6340
6350
6360
6370
6380
6390
6400
6410
6420
6430
6440
6450
LEGEND
MW-3 COMPLIANCE GROUNDWATER MONITOR WELL
MW-2 GROUNDWATER MONITOR WELL
FENCE
DIVERSION SWALE/DRAINAGE CHANNEL
WASTE DISPOSAL PERMIT AREA
FUTURE WASTE CELL BOUNDARY
CURRENT ACTIVE WASTE CELL
EXISTING ROAD
6200 GROUNDWATER ELEVATION CONTOUR (MEASURED 11/98)
0 100' 200'
Scale in Feet
FIGURE 2
DRAWN BY: BIX
PREPARED BY: DH
REVIEWED BY: DH
PROJ NO: 71.2558.3401
DATE PREPARED: 07-28-03
SITE MAP
THREE MILE CANYON LANDFILL
SUMMIT COUNTY, UTAH
ATC ASSOCIATES INC.
2681 East Parleys Way, Suite 106
Salt Lake City, Utah 84109


6360
6330
6300
6270
6240
6210
6180
6150
6120
6090
0
400
800
1200
1600
2000
MW-9
BEDROCK CONTACT
CURRENT GROUND SURFACE
ESTIMATED LIMITS OF WASTE
(MW-8, PROJECTED)
(GROUND SURFACE AT COMPLETION 7/86)
(PREVIOUS MEASUREMENT 8/86)
(MW-7, PROJECTED)
MW-4
MW-3
BEDDING PLANES
GROUNDWATER ELEVATIONS MEASURED 11/96
SCREENED INTERVAL
PROJECTED GROUNDWATER SURFACE
0 1 2
Scale in Feet
HORIZONTAL SCALE
0 1 2
Scale in Feet
VERTICAL SCALE
FIGURE 3
DRAWN BY: BX
PREPARED BY: DH
REVIEWED BY: DH
PROJ NO: 71.2556.3401
DATE PREPARED: 07-28-03
CROSS SECTION A-A'
THREE MILE CANYON LANDFILL
SUMMIT COUNTY, UTAH
ATC
ASSOCIATES INC.
2681 East Parleys Way, Suite 106
Salt Lake City, Utah 84109

ATTACHMENT 1

WELL LOGS AND COMPLETION DETAILS

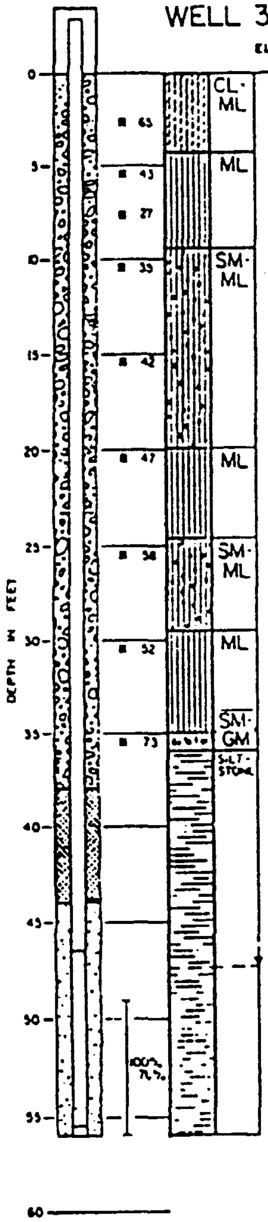
SUMMARY OF MONITOR WELL COMPLETION DETAILS AND ELEVATIONS
THREE MILE CANYON LANDFILL

Well ID	Location	Northing (feet)	Easting (feet)	Elevation Above Mean Sea Level (feet)						
				Sand Pack		Screen		Top of PVC	Ground Surface	Groundwater
				Top	Bottom	Top	Bottom			
MW-1	downgradient	11187.95	13759.52	6219.65	6209.65	6218.65	6210.15	6226.18	6223.65	dry
MW-2	downgradient	11106.79	13950.59	6159.95	6144.95	6154.95	6147.45	6185.42	6181.95	dry
MW-3	downgradient	11152.76	13967.76	6140.09	6128.09	6137.09	6127.59	6187.56	6184.09	6137.07
MW-4	downgradient	11146.32	13971.83	6113.57	6085.57	6105.57	6086.07	6187.04	6183.57	6121.71
MW-5	downgradient	11361.02	13197.28	9181.35	6164.35	6175.35	6165.35	6234.35	6231.01	dry
MW-6	downgradient	11362.76	13777.76	6133.83	6116.83	6127.83	6117.33	N/A	6186.83	dry
MW-7	downgradient	10880.67	13803.92	6123.40	6095.90	6122.90	6096.40	6191.04	6189.40	6146.86
MW-8	upgradient	10928.29	12986.83	6185.25	6109.75	6176.25	6156.25	N/A	6242.25	N/A
MW-9	upgradient	11282.90	12231.00	6217.50	6185.50	6211.20	6190.50	6327.80	6325.48	6298.10

N/A: Information not available

WELL 3

ELEVATION 6174'±



REDDISH-BROWN SILTY CLAY-CLAYEY SILT WITH SOME FINE TO COARSE SAND AND FINE GRAVEL-HARD

REDDISH-BROWN CLAYEY SILT WITH SOME FINE TO COARSE SAND-VERY STIFF

REDDISH-BROWN SILTY FINE TO COARSE SAND-FINE TO COARSE SANDY SILT-MEDIUM DENSE

REDDISH-BROWN SILT AND CLAYEY SILT WITH TRACE FINE SAND-VERY STIFF

REDDISH-BROWN SILTY FINE TO COARSE SAND-FINE TO COARSE SANDY SILT-DENSE

REDDISH-BROWN SILT AND CLAYEY SILT WITH SOME SAND AND TRACE GRAVEL-HARD

REDDISH-BROWN SILTY FINE TO COARSE SAND WITH SOME FINE AND COARSE GRAVEL-DENSE

REDDISH-BROWN SILTSTONE-MODERATELY HARD, CLOSELY TO MODERATELY FRACTURED AND JOINTED

WATER LEVEL AT 47.5 FEET ON 11-18-85

OBSERVATION WELL COMPLETED AT 56.0 FEET ON 11-13-85.

KEY

■ C

C BLOWS REQUIRED TO DRIVE A D&M TYPE U SAMPLER ONE FOOT WITH A 140 LB. HAMMER DROPPING 30 INCHES

■ DEPTH AT WHICH UNDISTURBED SAMPLE WAS EXTRACTED

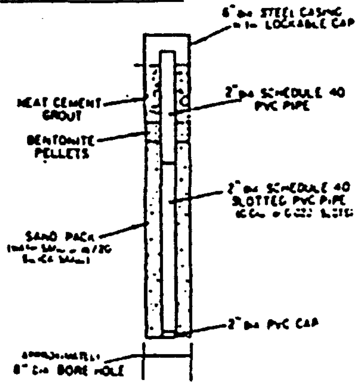
Σ DEPTH AT WHICH DISTURBED SAMPLE WAS EXTRACTED

— INTERVAL OF CORE ATTEMPT.

100% — PERCENT OF CORE RUN RECOVERED.

76% — RQD (ROCK QUALITY DESIGNATION) PERCENT OF TOTAL CORE RUN CONSISTING OF SOUND, UNFRACTURED PIECES 4 INCHES OR MORE IN LENGTH.

TYPICAL OBSERVATION WELL



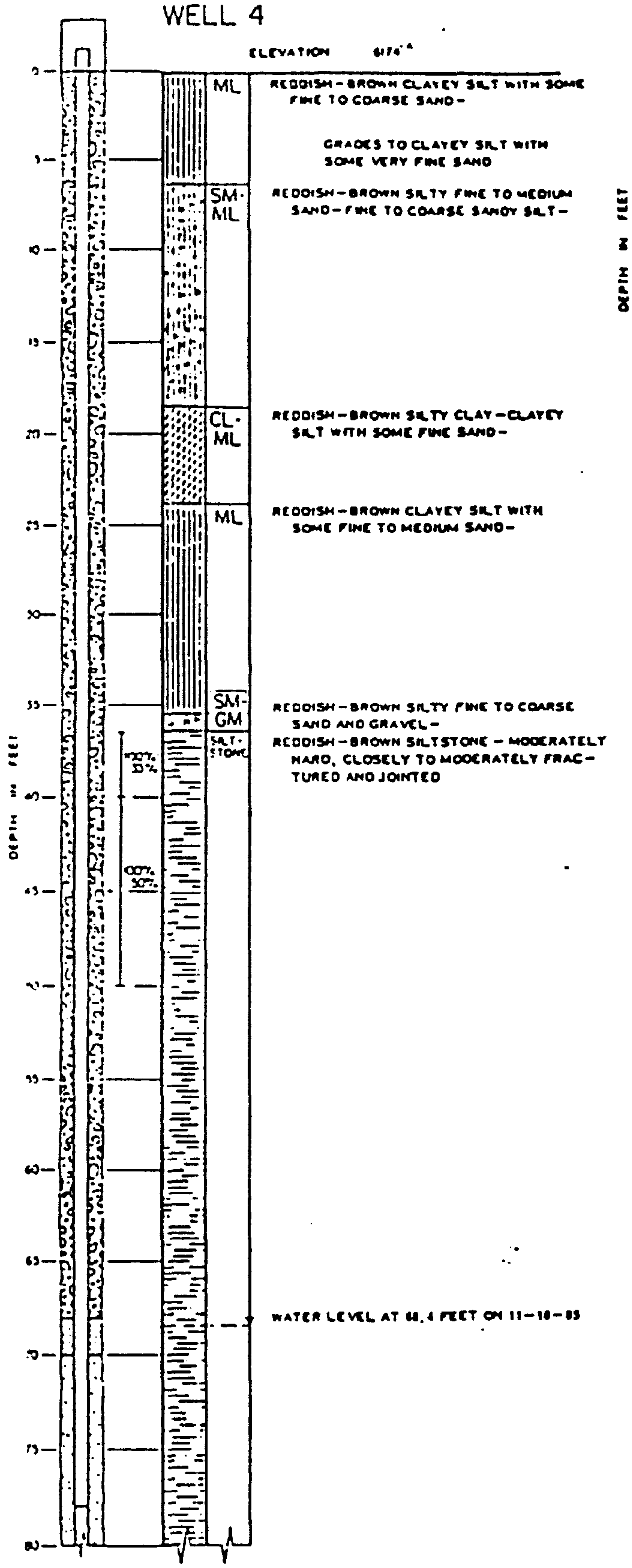
NOTES

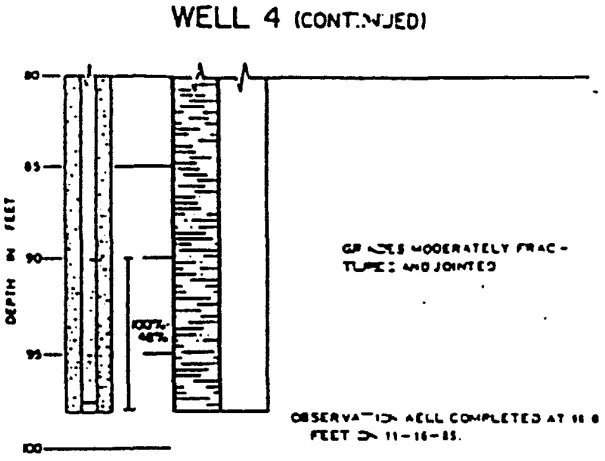
THE DISCUSSION IN THE TEXT UNDER THE SECTION TITLED, "SITE CONDITIONS, SUBSURFACE", IS NECESSARY TO A PROPER UNDERSTANDING OF THE NATURE OF THE SUBSURFACE MATERIALS.

GROUND SURFACE ELEVATIONS AT THE OBSERVATION WELL LOCATIONS WERE INTERPOLATED FROM THE TOPOGRAPHIC INFORMATION PRESENTED ON PLATE 2, PLOT PLAN.

LOG OF GROUND WATER OBSERVATION WELLS

Dames & Moore

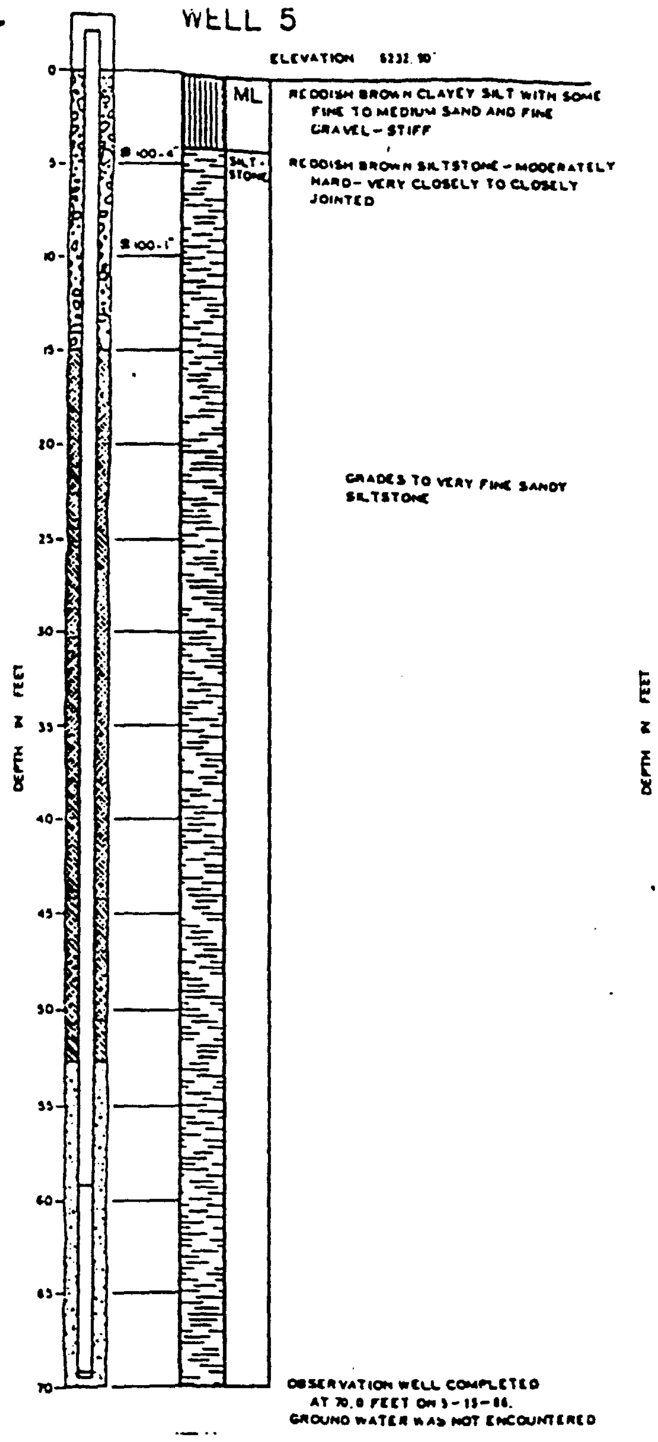


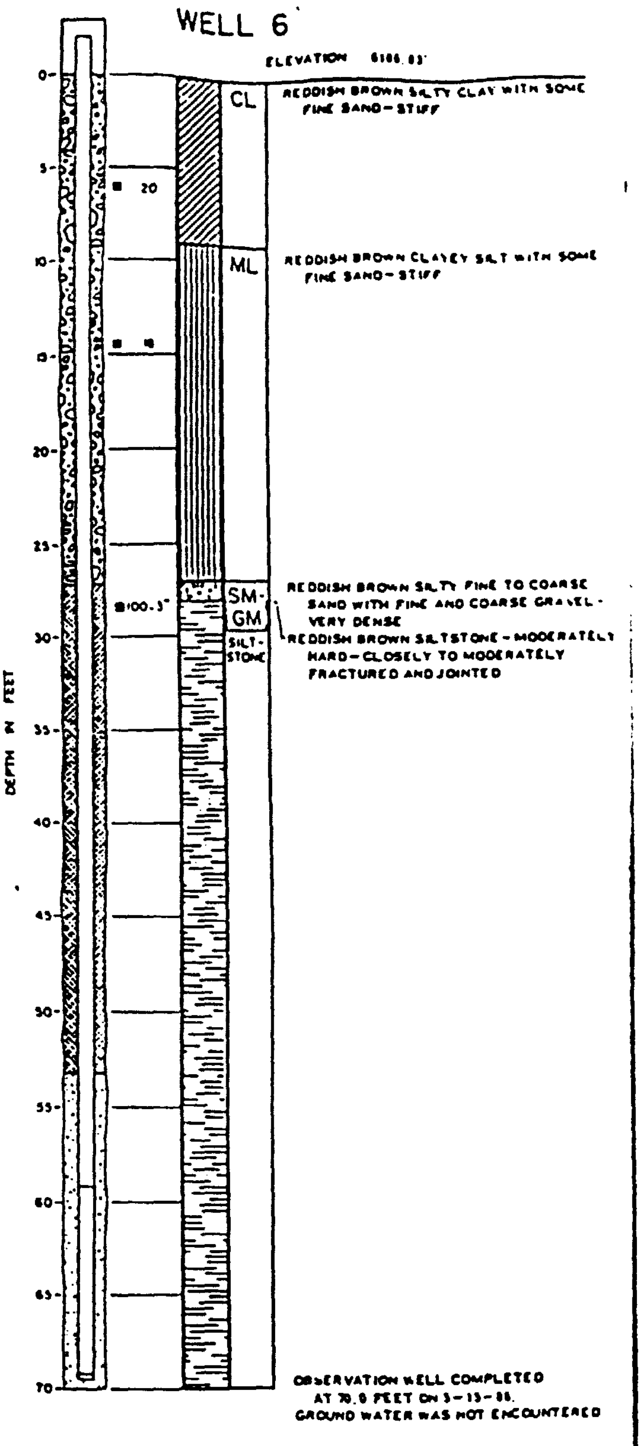


LOG OF GROUND WATER OBSERVATION WELLS

Dames & Moore

PLATE 38





KEY

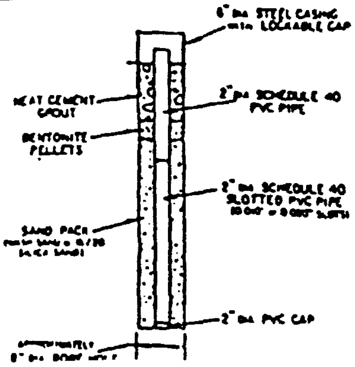
■ C

C BLOWS REQUIRED TO DRIVE A D&M TYPE U SAMPLER ONE FOOT WITH A 140 LB. HAMMER DROPPING 30 INCHES

■ DEPTH AT WHICH UNDISTURBED SAMPLE WAS EXTRACTED

■ DEPTH AT WHICH DISTURBED SAMPLE WAS EXTRACTED

TYPICAL OBSERVATION WELL



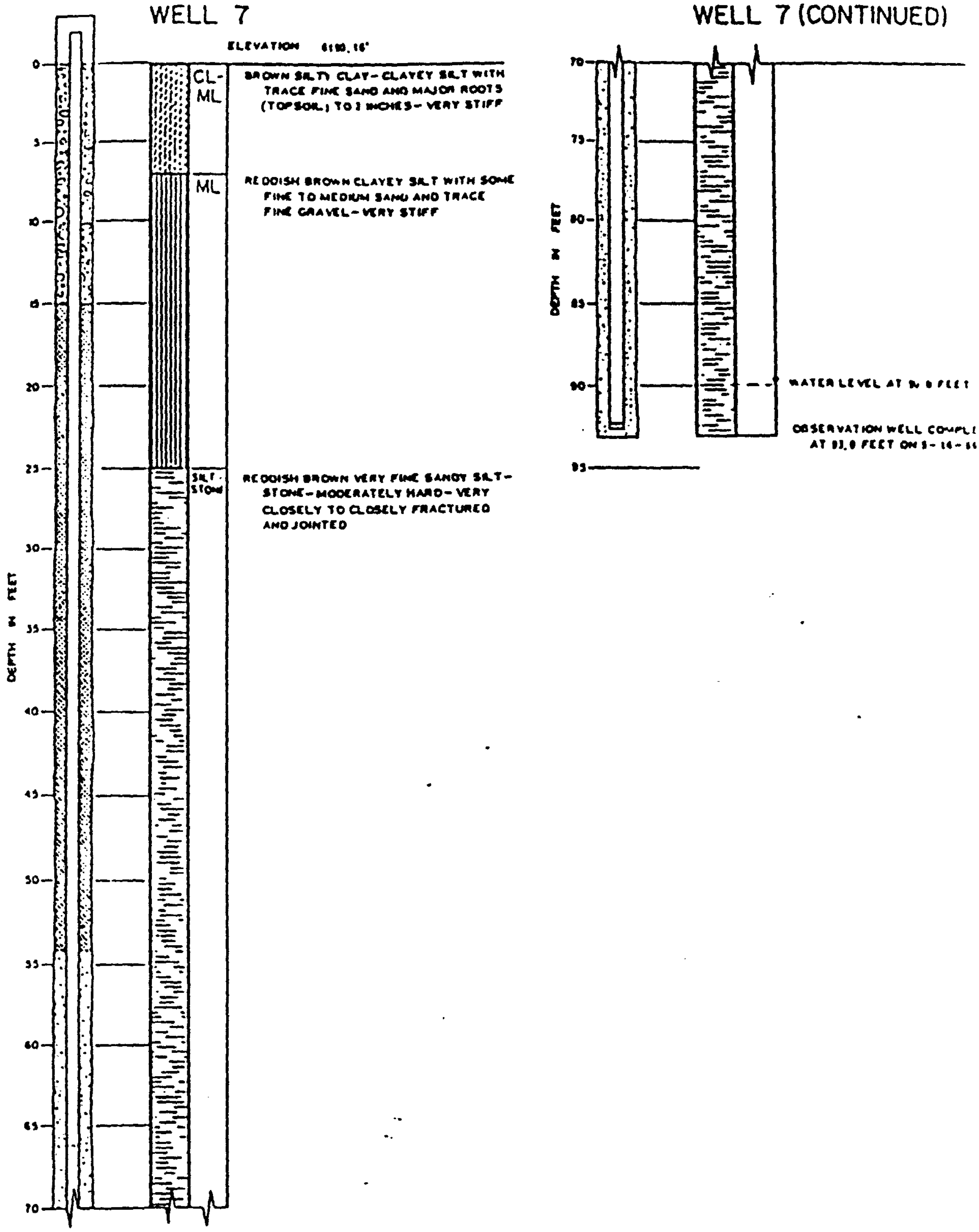
NOTES

THE DISCUSSION IN THE TEXT UNDER THE SECTION TITLED, "SITE CONDITIONS, SUBSURFACE", IS NECESSARY TO A PROPER UNDERSTANDING OF THE NATURE OF THE SUBSURFACE MATERIALS.

GROUND SURFACE ELEVATIONS AT THE OBSERVATION WELL LOCATIONS WERE PROVIDED BY A REPRESENTATIVE OF FORSGREN-PERKINS ENGINEERING P.A.

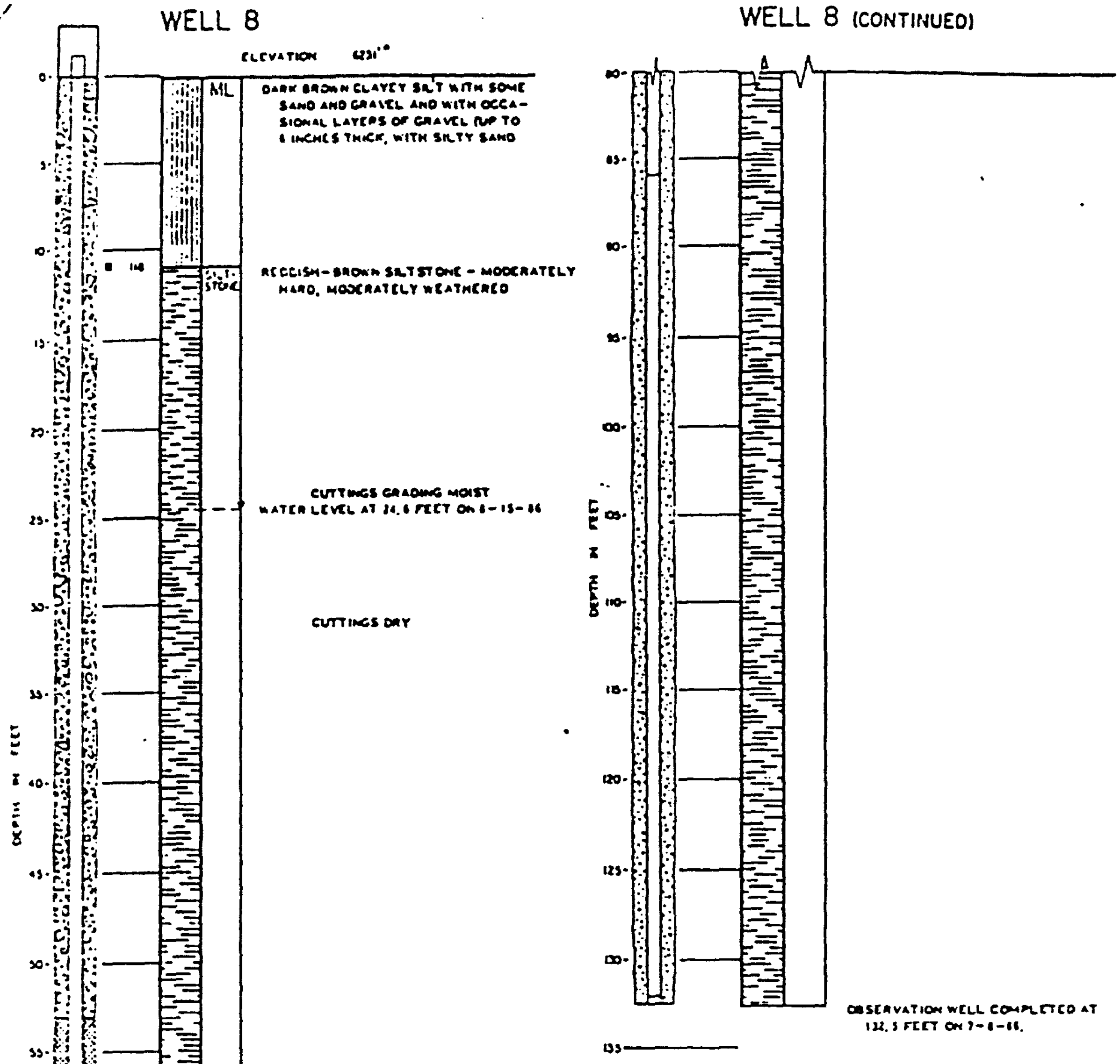
LOG OF GROUND WATER OBSERVATION WELLS

Dames & Moore



LOG OF GROUND WATER
OBSERVATION WELL

Dames & M



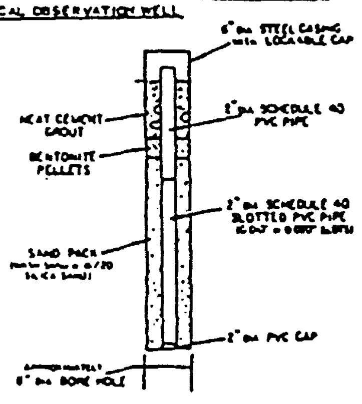
KEY

■ C

C BLOWS REQUIRED TO DRIVE A D&M TYPE U SAMPLER ONE FOOT WITH A 140 LB. HAMMER DROPPING 30 INCHES

■ DEPTH AT WHICH UNDISTURBED SAMPLE WAS EXTRACTED

TYPICAL OBSERVATION WELL



NOTES

THE DISCUSSION IN THE TEXT UNDER THE SECTION TITLED, "SITE CONDITIONS, SUBSURFACE", IS NECESSARY TO A PROPER UNDERSTANDING OF THE NATURE OF THE SUBSURFACE MATERIALS.

GROUND SURFACE ELEVATIONS AT THE OBSERVATION WELL LOCATIONS WERE PROVIDED BY A REPRESENTATIVE OF FORSGREN-PERKINS ENGINEERING P.A.

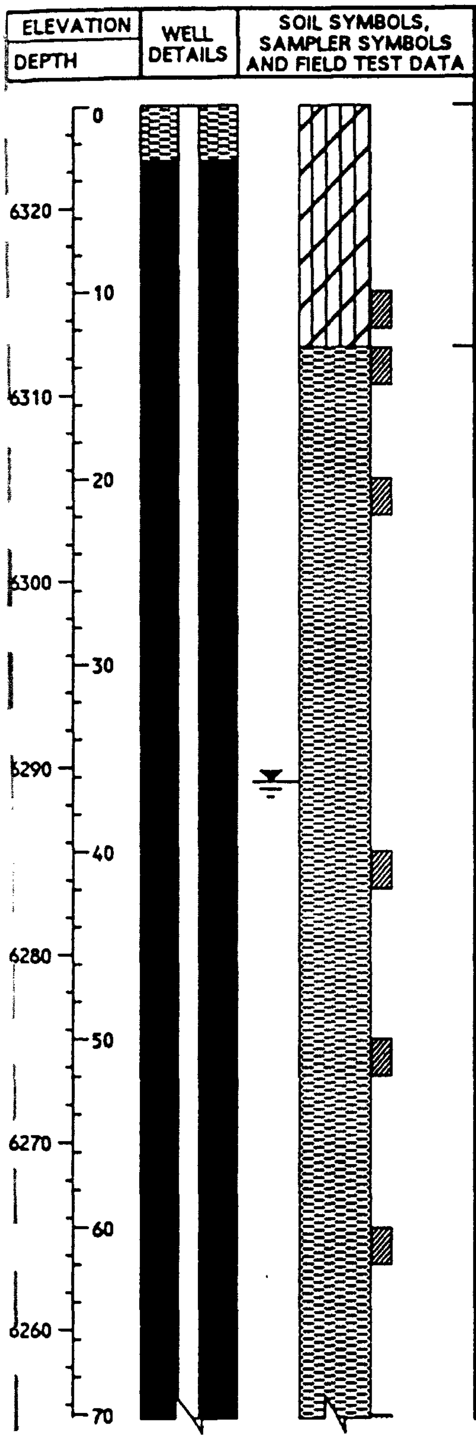
LOG OF GROUND WATER OBSERVATION WELL

Dames & Moore

DRILL HOLE LOG
MONITOR WELL NO.: MW-9

PROJECT: Three Mile Canyon Landfill
CLIENT/OWNER: Summit County
HOLE LOCATION: Upgradient well
DRILLER: Layne Environmental Services, Inc.
DRILL RIG: AP-1000
DEPTH TO WATER: 36.24 HOLE DIAMETER: 5.5"

PROJECT NO.: 1560-006
DATE: 3-17-94
TOC ELEV.: 6327.80
GS ELEV.: 6325.5
LOGGED BY: DH
WELL NO.: MW-9



USCS	Description	Sample Number	Sample Depth (ft)	Recovery (in/in)
CL-ML	CLAYEY SILT/SILTY CLAY: Brown, sandy, fine to medium, moist.			
		B-1	10-12	
		B-2	13-15	
	SILTSTONE: Reddish brown, moderatly hard, fractured and jointed, dry to moist.			
		B-3	20-22	
		B-4	40-42	
		B-5	50-52	
		B-6	60-62	

KEY TO SYMBOLS

Description	Symbol	Description
bols		Bentonite-cement slurry 2" O.D. blank PVC pipe
Silty clay/clayey silt		
Siltstone		Bentonite pellet plug 2" O.D. blank PVC pipe
		#10-20 silica sand 2" O.D. blank PVC pipe
mbols		
Boring continues		#10-20 silica sand 2" O.D. 20 slot PVC pipe
Water table		#10-20 silica sand
Drill hole completion depth		
plers		
Drill hole cuttings		
Well Details		
Protective well cover set in concrete		

or well MW-9 was drilled and installed on March 17 and 18, 1994.
le was drilled utilizing an AP-1000 truck mounted drill rig.
le was drilled to a depth of 20 feet advancing a 10-inch diameter
lual wall pipe using the percussion hammer drilling method, the
ing depth was drilled by advancing a 5.5-inch diameter (OD) dual
pe using the air rotary down hole hammer drilling method.

nd rock samples for identification were obtained from the drill
ttings.

to water level shown on drill hole log measured on May 6, 1994.

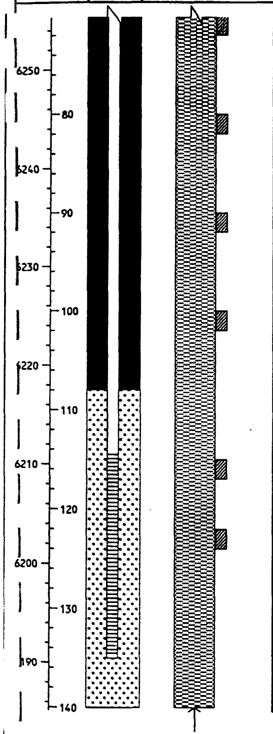
onitor well was surveyed to determine the horizontal and vertical
on based on Utelite facility coordinates and USGS Datum,
tively.

logs are subject to the limitations, conclusions, and
mendations in this report.

DRILL HOLE LOG
MONITOR WELL NO.: MW-9

PROJECT: Three Mile Canyon Landfill
CLIENT/OWNER: Summit County
HOLE LOCATION: Upgradient well
DRILLER: Layne Environmental Services, Inc.
DRILL RIG: AP-1000
DEPTH TO WATER: 36.24 HOLE DIAMETER: 5.5"

PROJECT NO.: 1560-006
DATE: 3-17-94
TOC ELEV.: 6327.80
GS ELEV.: 6325.5
LOGGED BY: DH
WELL NO.: MW-9



USCS	Description	Sample Number	Sample Depth (ft)	Recovery (in/in)
		B-7	70-72	
		B-8	80-82	
		B-9	90-92	
		B-10	100-102	
	...grades brown, hard, moist	B-11	115-117	
	...grades wet.	B-12	122-124	

ATTACHMENT 2

EXAMPLE FORMS

SUMMIT COUNTY LANDFILL
GROUNDWATER MONITORING DATA SHEET

Date: ______________________ Well ID/Sampling Location: ____________________

Job Number: ______________________ Time of Arrival at Well: ____________________

Owner: ______________________ Air Temperature: ____________________

Site Description: ______________________

Weather Conditions: ____

Sampled By: ____

Sampling Equipment: ____

Pump Depth (ft.): ______________________ Time Pump On: ____________________

Depth to Well Bottom (ft.): ______________________ Time Pump Off: ____________________

Depth to Groundwater (ft.): Purge Volume (gal.): ____________________

Presampling: ______________________ Purge Flow Rate (l/min.): ____________________

Postsampling: ______________________ Sample Flow Rate (l/min.): ____________________

Well in good condition? ☐Yes ☐No

Was lock secured upon arrival? ☐Yes ☐No

Is well operating correctly? ☐Yes ☐No

Explain any problems that may exist:

____

____

Time	PH	Dissolved Oxygen	Spec. Conductivity/Corrected	Temp.
			/	
			/	
			/	
			/	
			/	
			/	
			/	
			/	
			/	
			/	
			/	
			/	
			/	
			/	
			/	

Receiving Laboratory: ______________________ Date Received: ____________________

Comments:

____

____

____

____

____

Sampler's Initials: __________

Example Sample Label

Date ______________________ Time ______________________

Sampler ______________________________________

Sample ID ______________________________________

Description ____

____

____

Preservative ______________________

CHAIN OF CUSTODY

CLIENT ______________________

ADDRESS ______________________

____

PHONE/FAX ______________________

CONTACT ______________________

LAB # ______________________

SITE

SAMPLER'S SIGNATURE

SAMPLE ID	SAMPLE DATE/TIME	MATRIX	# OF CONTAINERS	BTX/TPH	VOLATILES	SEMIVOLATILES	D LIST METALS	ET PROFILE														TURN AROUND TIME	COMMENTS

TURN AROUND TIMES
I = Priority I
II = Priority II
III = 5 Day Rush
S = Standard

Quote # /P.O. # ______________________

Special Instructions: ______________________

Relinquished By: *Signature*	Date/Time	Received By: *Signature*	Date/Time
PRINT NAME		PRINT NAME	
Relinquished By: *Signature*	Date/Time	Received By: *Signature*	Date/Time
PRINT NAME		PRINT NAME	
Dispatched By: *Signature*	Date/Time	Received for Laboratory By:	Date/Time
PRINT NAME		PRINT NAME	

SAMPLE FORMS

SUMMIT COUNTY LANDFILL DAILY OPERATING FORM

Date: ______________________________

Operator: ______________________________

Load No.	General Description of Load	Estimated Weight of Load
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		

LOAD INSPECTION RECORD

Date: ____________________

Operator: ____________________

Load No. ______________

General Desription of Waste ____

____

____

Inspection Method ____

Results of Inspection ____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

Summary: Any PCBs or hazardous waste found?

Yes ______ No ________

Inspector Signature: ____________________________________

SUMMIT COUNTY LANDFILL
QUARTERLY INSPECTION RECORD

Date: ______________________

Time: ______________________

Inspector Name: ______________________________

Inspection to include (but not limited to) storm water run-on/run-off controls, access road condition, litter control fence, litter condition, monitor well condition, and gate condition.

Observations: ____

____

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____

____

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____

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____

Repairs or Corrective Actions: ____

____

____

____

____

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____

____

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____

____

____

____

____

____

Inspector Signature: ______________________________

SUMMIT COUNTY LANDFILL GAS MONITORING FORM

Date: ____________________

Weather: ____________________

Name: ____________________

Instrument Used: ____________________

FACILITY BUILDINGS

Building Location: ____________________

Percent of Methane LEL: ____________________

Building Location: ____________________

Percent of Methane LEL: ____________________

Results (exceed 25% LEL?): ____________________

PROPERTY BOUNDARY

Sampling Location*: ____________________

Percent of LEL: ____________________

Sampling Location*: ____________________

Percent of LEL: ____________________

Sampling Location*: ____________________

Percent of LEL: ____________________

Sampling Location*: ____________________

Percent of LEL: ____________________

Results (exceed 100% LEL?): ____________________

*See Sheet 2 of the 1996 Permit Application

SUMMARY

Do gas levels exceed permitted LEL's? Yes ______ No* ______

*Submit an application for discontinuing gas monitoring if gas levels are below permitted LEL values for 2 consecutive years after closure.

SUMMIT COUNTY LANDFILL
GROUNDWATER MONITORING DATA SHEET

Date: ____________________ Well ID/Sampling Location: ____________________

Job Number: ____________________ Time of Arrival at Well: ____________________

Owner: ____________________ Air Temperature: ____________________

Site Description: ____________________

Weather Conditions: ____

Sampled By: ____

Sampling Equipment: ____

Pump Depth (ft.): ____________________ Time Pump On: ____________________

Depth to Well Bottom (ft.): ____________________ Time Pump Off: ____________________

Depth to Groundwater (ft.): Purge Volume (gal.): ____________________

Presampling: ____________________ Purge Flow Rate (l/min.): ____________________

Postsampling: ____________________ Sample Flow Rate (l/min.): ____________________

Well in good condition? ☐Yes ☐No

Was lock secured upon arrival? ☐Yes ☐No

Is well operating correctly? ☐Yes ☐No

Explain any problems that may exist: ____

____

Time	PH	Dissolved Oxygen	Spec. Conductivity/Corrected	Temp.
			/	
			/	
			/	
			/	
			/	
			/	
			/	
			/	
			/	
			/	
			/	
			/	
			/	
			/	
			/	

Receiving Laboratory: ____________________ Date Received: ____________________

Comments:

____

____

____

____

____

Sampler's Initials: __________

APPENDIX C

ENGINEERING CALCULATIONS

LANDFILL VOLUME REQUIREMENT CALCULATIONS

Projected Population Growth and Waste Disposal Requirments
Summit County, Utah

Year	Population	Percent Increase	Municipal Waste (TPY)	Non-Resident Waste (TPY)	Industrial Waste (TPY)	Construction Waste (TPY)	TOTAL (TPY)	Cumulative Total (tons)
2003	32,831		26,512	3,464	12,991	6,894	49,861	49,861
2004	34,028	3.6	27,466	3,589	13,459	7,142	51,656	101,517
2005	35,162	3.3	28,455	3,707	13,903	7,378	53,443	154,960
2006	36,368	3.4	29,480	3,833	14,376	7,629	55,317	210,277
2007	37,643	3.5	30,541	3,967	14,879	7,896	57,283	267,560
2008	38,959	3.5	31,640	4,106	15,399	8,172	59,318	326,878
2009	40,454	3.8	32,779	4,262	15,985	8,483	61,509	388,387
2010	41,988	3.8	33,959	4,424	16,592	8,805	63,781	452,167
2011	43,464	3.5	35,182	4,579	17,173	9,113	66,047	518,214

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
HELP MODEL

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**                                                                          **
**                                                                          **
**         HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                    **
**         HELP MODEL VERSION 3.01   (14 OCTOBER 1994)                      **
**           DEVELOPED BY ENVIRONMENTAL LABORATORY                          **
**             USAE WATERWAYS EXPERIMENT STATION                            **
**         FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                  **
**                                                                          **
**                                                                          **
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TIME: 14:50   DATE: 2/ 7/1995

****

TITLE: THREE MILE CANYON

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NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

LAYER 1

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 8

```
THICKNESS                    =    6.00  INCHES
POROSITY                     =    0.4630 VOL/VOL
FIELD CAPACITY               =    0.2320 VOL/VOL
WILTING POINT                =    0.1160 VOL/VOL
INITIAL SOIL WATER CONTENT   =    0.2131 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =    0.369999994000E-03 CM/SEC
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NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY 2.49
FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

LAYER 2

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS = 18.00 INCHES
POROSITY = 0.4270 VOL/VOL
FIELD CAPACITY = 0.4180 VOL/VOL
WILTING POINT = 0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.100000001000E-06 CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS = 1200.00 INCHES
POROSITY = 0.6710 VOL/VOL
FIELD CAPACITY = 0.2920 VOL/VOL
WILTING POINT = 0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2920 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.100000005000E-02 CM/SEC

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS = 24.00 INCHES
POROSITY = 0.4270 VOL/VOL
FIELD CAPACITY = 0.4180 VOL/VOL
WILTING POINT = 0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.100000001000E-06 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER = 75.00
FRACTION OF AREA ALLOWING RUNOFF = 100.0 PERCENT
AREA PROJECTED ON HORIZONTAL PLANE = 23.600 ACRES
EVAPORATIVE ZONE DEPTH = 6.0 INCHES
INITIAL WATER IN EVAPORATIVE ZONE = 1.279 INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE = 2.778 INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE = 0.696 INCHES
INITIAL SNOW WATER = 0.000 INCHES
INITIAL WATER IN LAYER MATERIALS = 369.632 INCHES
TOTAL INITIAL WATER = 369.632 INCHES
TOTAL SUBSURFACE INFLOW = 0.00 INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Salt Lake City Utah

MAXIMUM LEAF AREA INDEX = 1.60
START OF GROWING SEASON (JULIAN DATE) = 117
END OF GROWING SEASON (JULIAN DATE) = 289
AVERAGE ANNUAL WIND SPEED = 8.80 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 67.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 48.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 39.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 65.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SALT LAKE UTAH

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.17	1.12	1.52	1.80	1.68	1.14
1.13	1.08	1.50	1.53	1.61	1.34

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SALT LAKE UTAH

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
22.90	26.70	33.80	42.50	51.00	59.10
66.20	64.70	56.00	45.70	34.10	24.60

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SALT LAKE UTAH

STATION LATITUDE = 40.76 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.89	1.26	1.39	1.74	1.42	1.19
	1.20	1.08	1.79	1.13	1.48	1.49
STD. DEVIATIONS	0.70	0.66	0.92	1.02	0.79	0.72
	0.67	0.66	0.76	0.80	1.08	0.90
RUNOFF						
TOTALS	0.000	0.000	0.925	0.013	0.010	0.000
	0.000	0.000	0.006	0.000	0.080	0.000
STD. DEVIATIONS	0.000	0.000	0.769	0.072	0.056	0.000
	0.000	0.000	0.033	0.000	0.244	0.000
EVAPOTRANSPIRATION						
TOTALS	0.711	0.826	1.465	1.880	1.544	1.311
	1.074	1.074	1.548	1.200	0.895	0.858
STD. DEVIATIONS	0.185	0.093	0.364	0.824	0.751	0.757
	0.679	0.756	0.803	0.586	0.532	0.212

PERCOLATION/LEAKAGE THROUGH LAYER 2

TOTALS	0.0554	0.0113	0.0601	0.0777	0.0595	0.0499
	0.0293	0.0365	0.0520	0.0544	0.0635	0.0701
STD. DEVIATIONS	0.0539	0.0128	0.0223	0.0412	0.0412	0.0362
	0.0342	0.0383	0.0376	0.0378	0.0451	0.0533

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0552	0.0228	0.0537	0.0738	0.0609	0.0528
	0.0326	0.0372	0.0508	0.0544	0.0583	0.0670
STD. DEVIATIONS	0.0524	0.0257	0.0191	0.0352	0.0403	0.0370
	0.0350	0.0386	0.0355	0.0353	0.0389	0.0503

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ACROSS LAYER 2

AVERAGES	0.1707	0.0070	1.0928	1.2801	0.7112	0.3697
	0.2241	0.2667	0.5072	0.6316	1.3468	0.6987
STD. DEVIATIONS	0.1736	0.0091	0.7878	1.2136	0.7430	0.4047
	0.3689	0.3933	0.4632	0.6730	1.5553	0.6435

DAILY AVERAGE HEAD ACROSS LAYER 4

AVERAGES	0.0299	0.0122	0.0050	0.0243	0.0287	0.0196
	0.0112	0.0071	0.0056	0.0086	0.0130	0.0284
STD. DEVIATIONS	0.0350	0.0164	0.0038	0.0221	0.0349	0.0336
	0.0286	0.0227	0.0069	0.0116	0.0145	0.0321

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	16.06	(2.857)	1375971.2	100.00
RUNOFF	1.035	(0.8491)	88663.67	6.444
EVAPOTRANSPIRATION	14.386	(2.1541)	1232385.25	89.565
PERCOLATION/LEAKAGE THROUGH FROM LAYER 2	0.61947	(0.18380)	53068.715	3.85682
AVERAGE HEAD ACROSS TOP OF LAYER 2	0.609	(0.278)		
PERCOLATION/LEAKAGE THROUGH FROM LAYER 4	0.61952	(0.18462)	53073.133	3.85714
AVERAGE HEAD ACROSS TOP OF LAYER 4	0.016	(0.012)		
CHANGE IN WATER STORAGE	0.022	(1.0879)	1849.02	0.134

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	1.80	154202.391
RUNOFF	0.794	68038.1016
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.004535	388.53632
AVERAGE HEAD ACROSS LAYER 2	6.000	
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.003422	293.12811
AVERAGE HEAD ACROSS LAYER 4	0.142	
SNOW WATER	4.23	362431.9370
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4630	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0865	

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	1.8088	0.3015
2	7.6860	0.4270
3	350.4180	0.2920
4	10.2480	0.4270

SNOW WATER 0.000

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STABILITY MODELING CALCULATIONS

** PCSTABL5M **

1

by
Purdue University

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer's Method of Slices

Run Date:	1/3/96
Time of Run:	5:00
Run By:	HUSK
Input Data Filename:	STATRUNE.DAT
Output Filename:	STATRUNE.OUT
Plotted Output Filename:	STATRUNE.PLT

PROBLEM DESCRIPTION Summit County Landfill - Run E - Static
(flatten toe of slope)

BOUNDARY COORDINATES

5 Top Boundaries
5 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	5.00	177.00	55.00	177.00	1
2	55.00	177.00	185.00	220.00	1
3	185.00	220.00	265.00	260.00	1
4	265.00	260.00	525.00	318.00	1
5	525.00	318.00	575.00	318.00	1

1

ISOTROPIC SOIL PARAMETERS

1 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	110.0	130.0	1500.0	29.0	.00	.0	1

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

300 Trial Surfaces Have Been Generated.

34	366.74	201.61
35	375.64	206.18
36	384.43	210.95
37	393.10	215.92
38	401.66	221.09
39	410.09	226.47
40	418.40	232.04
41	426.57	237.80
42	434.61	243.75
43	442.51	249.88
44	450.26	256.20
45	457.86	262.70
46	465.30	269.38
47	472.59	276.22
48	479.72	283.24
49	486.68	290.42
50	493.47	297.76
51	500.08	305.26
52	506.53	312.91
53	507.47	314.09

Circle Center At X = 175.9 ; Y = 584.7 and Radius, 428.0

*** 3.058 ***

Individual data on the 55 slices

Slice No.	Width Ft(m)	Weight Lbs(kg)	Water Force Top Lbs(kg)	Water Force Bot Lbs(kg)	Tie Force Norm Lbs(kg)	Tie Force Tan Lbs(kg)	Earthquake Force Hor Lbs(kg)	Earthquake Force Ver Lbs(kg)	Surcharge Load Lbs(kg)
1	9.2	1429.5	.0	.0	.0	.0	.0	.0	.0
2	.4	113.3	.0	.0	.0	.0	.0	.0	.0
3	9.6	6344.1	.0	.0	.0	.0	.0	.0	.0
4	9.7	12551.0	.0	.0	.0	.0	.0	.0	.0
5	9.7	18602.7	.0	.0	.0	.0	.0	.0	.0
6	9.8	24482.4	.0	.0	.0	.0	.0	.0	.0
7	9.8	30173.9	.0	.0	.0	.0	.0	.0	.0
8	9.9	35661.9	.0	.0	.0	.0	.0	.0	.0
9	9.9	40931.8	.0	.0	.0	.0	.0	.0	.0
10	9.9	45969.8	.0	.0	.0	.0	.0	.0	.0
11	10.0	50763.1	.0	.0	.0	.0	.0	.0	.0
12	10.0	55299.5	.0	.0	.0	.0	.0	.0	.0
13	10.0	59568.1	.0	.0	.0	.0	.0	.0	.0
14	10.0	63558.8	.0	.0	.0	.0	.0	.0	.0
15	10.0	67262.3	.0	.0	.0	.0	.0	.0	.0
16	1.3	9018.3	.0	.0	.0	.0	.0	.0	.0
17	8.7	62355.8	.0	.0	.0	.0	.0	.0	.0
18	10.0	76320.7	.0	.0	.0	.0	.0	.0	.0
19	10.0	80966.1	.0	.0	.0	.0	.0	.0	.0
20	10.0	85285.6	.0	.0	.0	.0	.0	.0	.0
21	9.9	89270.9	.0	.0	.0	.0	.0	.0	.0
22	9.9	92915.1	.0	.0	.0	.0	.0	.0	.0
23	9.9	96212.5	.0	.0	.0	.0	.0	.0	.0
24	9.8	99158.1	.0	.0	.0	.0	.0	.0	.0
25	1.9	19704.9	.0	.0	.0	.0	.0	.0	.0
26	7.9	81104.3	.0	.0	.0	.0	.0	.0	.0
27	9.7	100220.5	.0	.0	.0	.0	.0	.0	.0
28	9.7	99268.5	.0	.0	.0	.0	.0	.0	.0
29	9.6	98014.0	.0	.0	.0	.0	.0	.0	.0
30	9.5	96464.3	.0	.0	.0	.0	.0	.0	.0

31	9.4	94626.9	.0	.0	.0	.0	.0	.0	.0
32	9.4	92510.4	.0	.0	.0	.0	.0	.0	.0
33	9.3	90123.8	.0	.0	.0	.0	.0	.0	.0
34	9.2	87478.4	.0	.0	.0	.0	.0	.0	.0
35	9.1	84585.2	.0	.0	.0	.0	.0	.0	.0
36	9.0	81456.0	.0	.0	.0	.0	.0	.0	.0
37	8.9	78104.0	.0	.0	.0	.0	.0	.0	.0
38	8.8	74543.5	.0	.0	.0	.0	.0	.0	.0
39	8.7	70788.2	.0	.0	.0	.0	.0	.0	.0
40	8.6	66854.0	.0	.0	.0	.0	.0	.0	.0
41	8.4	62756.7	.0	.0	.0	.0	.0	.0	.0
42	8.3	58512.5	.0	.0	.0	.0	.0	.0	.0
43	8.2	54139.1	.0	.0	.0	.0	.0	.0	.0
44	8.0	49654.2	.0	.0	.0	.0	.0	.0	.0
45	7.9	45075.9	.0	.0	.0	.0	.0	.0	.0
46	7.7	40423.1	.0	.0	.0	.0	.0	.0	.0
47	7.6	35714.9	.0	.0	.0	.0	.0	.0	.0
48	7.4	30970.9	.0	.0	.0	.0	.0	.0	.0
49	7.3	26211.1	.0	.0	.0	.0	.0	.0	.0
50	7.1	21455.7	.0	.0	.0	.0	.0	.0	.0
51	7.0	16724.9	.0	.0	.0	.0	.0	.0	.0
52	6.8	12039.6	.0	.0	.0	.0	.0	.0	.0
53	6.6	7420.4	.0	.0	.0	.0	.0	.0	.0
54	6.4	2888.3	.0	.0	.0	.0	.0	.0	.0
55	.9	50.6	.0	.0	.0	.0	.0	.0	.0

Failure Surface Specified By 54 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	40.53	177.00
2	50.02	173.85
3	59.58	170.93
4	69.21	168.23
5	78.90	165.76
6	88.65	163.52
7	98.44	161.52
8	108.29	159.74
9	118.17	158.20
10	128.08	156.89
11	138.02	155.82
12	147.99	154.99
13	157.97	154.39
14	167.96	154.02
15	177.96	153.90
16	187.96	154.01
17	197.96	154.35
18	207.94	154.94
19	217.90	155.76
20	227.85	156.81
21	237.77	158.10
22	247.65	159.63
23	257.49	161.39
24	267.29	163.38
25	277.04	165.60
26	286.74	168.05
27	296.37	170.73
28	305.94	173.64
29	315.43	176.78
30	324.85	180.13
31	334.19	183.72
32	343.44	187.52
33	352.60	191.53
34	361.66	195.77

35	370.61	200.21
36	379.46	204.87
37	388.20	209.74
38	396.82	214.81
39	405.31	220.08
40	413.68	225.56
41	421.92	231.23
42	430.02	237.09
43	437.98	243.15
44	445.79	249.39
45	453.46	255.81
46	460.97	262.41
47	468.32	269.19
48	475.51	276.14
49	482.53	283.26
50	489.38	290.55
51	496.06	297.99
52	502.56	305.59
53	508.87	313.34
54	509.87	314.62

Circle Center At X = 178.3 ; Y = 576.2 and Radius, 422.3

*** 3.060 ***

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Failure Surface Specified By 54 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	40.53	177.00
2	50.04	173.92
3	59.62	171.06
4	69.27	168.42
5	78.97	166.00
6	88.73	163.81
7	98.53	161.84
8	108.38	160.10
9	118.26	158.58
10	128.18	157.29
11	138.12	156.23
12	148.09	155.40
13	158.07	154.80
14	168.06	154.43
15	178.06	154.29
16	188.06	154.37
17	198.06	154.69
18	208.04	155.24
19	218.01	156.02
20	227.96	157.02
21	237.88	158.26
22	247.78	159.72
23	257.63	161.41
24	267.45	163.33
25	277.22	165.47
26	286.93	167.84
27	296.59	170.42
28	306.19	173.23
29	315.72	176.26
30	325.18	179.51

31	334.56	182.98
32	343.86	186.66
33	353.07	190.55
34	362.19	194.65
35	371.21	198.96
36	380.13	203.48
37	388.94	208.20
38	397.65	213.13
39	406.24	218.25
40	414.70	223.57
41	423.05	229.08
42	431.26	234.78
43	439.34	240.67
44	447.29	246.75
45	455.09	253.00
46	462.75	259.44
47	470.25	266.04
48	477.60	272.82
49	484.80	279.77
50	491.83	286.88
51	498.70	294.15
52	505.40	301.57
53	511.92	309.15
54	517.90	316.42

Circle Center At X = 179.2 ; Y = 589.1 and Radius, 434.8

*** 3.062 ***

Failure Surface Specified By 57 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	30.00	177.00
2	39.51	173.91
3	49.09	171.04
4	58.73	168.37
5	68.42	165.91
6	78.16	163.66
7	87.95	161.63
8	97.79	159.81
9	107.66	158.20
10	117.56	156.81
11	127.49	155.64
12	137.45	154.68
13	147.42	153.94
14	157.40	153.42
15	167.40	153.11
16	177.40	153.02
17	187.40	153.15
18	197.39	153.50
19	207.38	154.06
20	217.35	154.85
21	227.30	155.85
22	237.22	157.06
23	247.12	158.49
24	256.98	160.14
25	266.81	162.00
26	276.59	164.08
27	286.32	166.36

28	296.01	168.86
29	305.63	171.57
30	315.20	174.49
31	324.70	177.62
32	334.13	180.95
33	343.48	184.48
34	352.75	188.22
35	361.95	192.16
36	371.05	196.30
37	380.06	200.64
38	388.97	205.17
39	397.79	209.90
40	406.49	214.81
41	415.09	219.92
42	423.58	225.21
43	431.95	230.68
44	440.19	236.34
45	448.32	242.17
46	456.31	248.18
47	464.17	254.36
48	471.90	260.71
49	479.48	267.23
50	486.92	273.91
51	494.21	280.76
52	501.35	287.75
53	508.34	294.91
54	515.17	302.21
55	521.84	309.66
56	528.35	317.26
57	528.96	318.00

Circle Center At X = 176.4 ; Y = 612.2 and Radius, 459.1

*** 3.064 ***

1

Failure Surface Specified By 57 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	30.00	177.00
2	39.56	174.06
3	49.18	171.32
4	58.85	168.79
5	68.58	166.46
6	78.35	164.34
7	88.16	162.42
8	98.02	160.72
9	107.90	159.22
10	117.82	157.93
11	127.76	156.86
12	137.72	155.99
13	147.70	155.34
14	157.69	154.89
15	167.69	154.66
16	177.69	154.64
17	187.69	154.83
18	197.68	155.23
19	207.66	155.85
20	217.63	156.67

21	227.57	157.71
22	237.50	158.96
23	247.39	160.41
24	257.25	162.08
25	267.07	163.95
26	276.85	166.03
27	286.59	168.32
28	296.27	170.82
29	305.90	173.51
30	315.47	176.42
31	324.98	179.52
32	334.42	182.82
33	343.78	186.33
34	353.07	190.03
35	362.28	193.92
36	371.41	198.01
37	380.44	202.30
38	389.39	206.77
39	398.23	211.43
40	406.98	216.28
41	415.62	221.31
42	424.16	226.52
43	432.58	231.92
44	440.88	237.49
45	449.07	243.23
46	457.13	249.15
47	465.06	255.24
48	472.87	261.49
49	480.54	267.91
50	488.07	274.48
51	495.46	281.22
52	502.71	288.11
53	509.81	295.15
54	516.76	302.34
55	523.55	309.68
56	530.19	317.16
57	530.90	318.00

Circle Center At X = 173.7 ; Y = 626.9 and Radius, 472.3

*** 3.065 ***

Failure Surface Specified By 54 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	43.16	177.00
2	52.82	174.40
3	62.53	172.01
4	72.28	169.83
5	82.09	167.85
6	91.93	166.08
7	101.81	164.52
8	111.71	163.17
9	121.65	162.02
10	131.61	161.09
11	141.58	160.37
12	151.57	159.86
13	161.56	159.56
14	171.56	159.47

15	181.56	159.60
16	191.55	159.93
17	201.54	160.48
18	211.51	161.24
19	221.46	162.20
20	231.39	163.38
21	241.30	164.77
22	251.17	166.37
23	261.01	168.17
24	270.80	170.19
25	280.55	172.40
26	290.25	174.83
27	299.90	177.46
28	309.49	180.29
29	319.02	183.33
30	328.48	186.56
31	337.87	190.00
32	347.19	193.63
33	356.43	197.46
34	365.58	201.49
35	374.65	205.70
36	383.62	210.11
37	392.51	214.71
38	401.29	219.49
39	409.97	224.46
40	418.54	229.61
41	427.00	234.94
42	435.35	240.45
43	443.57	246.13
44	451.68	251.99
45	459.66	258.01
46	467.51	264.21
47	475.23	270.56
48	482.81	277.08
49	490.26	283.76
50	497.56	290.60
51	504.71	297.58
52	511.71	304.72
53	518.57	312.00
54	523.71	317.71

Circle Center At X = 170.7 ; Y = 632.3 and Radius, 472.8

*** 3.065 ***

1

Failure Surface Specified By 54 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	53.68	177.00
2	63.38	174.55
3	73.13	172.31
4	82.91	170.26
5	92.74	168.42
6	102.61	166.78
7	112.50	165.35
8	122.43	164.12
9	132.38	163.09
10	142.34	162.27

11	152.32	161.65
12	162.31	161.24
13	172.31	161.04
14	182.31	161.04
15	192.31	161.25
16	202.30	161.66
17	212.28	162.28
18	222.25	163.11
19	232.20	164.14
20	242.12	165.37
21	252.01	166.81
22	261.88	168.45
23	271.71	170.30
24	281.49	172.35
25	291.24	174.60
26	300.93	177.05
27	310.58	179.69
28	320.16	182.54
29	329.69	185.58
30	339.15	188.82
31	348.54	192.26
32	357.86	195.88
33	367.10	199.70
34	376.27	203.71
35	385.34	207.90
36	394.33	212.28
37	403.23	216.85
38	412.03	221.60
39	420.73	226.53
40	429.33	231.63
41	437.82	236.91
42	446.20	242.37
43	454.47	248.00
44	462.62	253.80
45	470.64	259.76
46	478.55	265.89
47	486.32	272.18
48	493.96	278.62
49	501.47	285.23
50	508.84	291.99
51	516.07	298.89
52	523.16	305.95
53	530.10	313.15
54	534.59	318.00

Circle Center At X = 177.2 ; Y = 646.2 and Radius, 485.2

*** 3.068 ***

Failure Surface Specified By 57 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	35.26	177.00
2	44.90	174.31
3	54.58	171.82
4	64.31	169.52
5	74.09	167.42
6	83.90	165.51
7	93.76	163.79

8	103.64	162.28
9	113.55	160.96
10	123.49	159.84
11	133.45	158.92
12	143.42	158.19
13	153.41	157.67
14	163.40	157.34
15	173.40	157.22
16	183.40	157.29
17	193.40	157.57
18	203.39	158.04
19	213.36	158.71
20	223.33	159.58
21	233.27	160.65
22	243.19	161.92
23	253.08	163.39
24	262.94	165.05
25	272.77	166.91
26	282.55	168.97
27	292.30	171.22
28	301.99	173.66
29	311.64	176.30
30	321.23	179.13
31	330.76	182.15
32	340.24	185.35
33	349.64	188.75
34	358.98	192.34
35	368.24	196.11
36	377.42	200.06
37	386.53	204.20
38	395.55	208.52
39	404.48	213.01
40	413.32	217.69
41	422.07	222.54
42	430.71	227.56
43	439.26	232.75
44	447.70	238.12
45	456.03	243.65
46	464.25	249.34
47	472.35	255.20
48	480.34	261.22
49	488.20	267.40
50	495.94	273.74
51	503.55	280.22
52	511.03	286.86
53	518.37	293.65
54	525.58	300.58
55	532.65	307.65
56	539.58	314.86
57	542.47	318.00

Circle Center At X = 174.7 ; Y = 658.4 and Radius, 501.1

*** 3.071 ***

Failure Surface Specified By 54 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)

1	45.79	177.00
2	55.54	174.76
3	65.32	172.71
4	75.15	170.86
5	85.01	169.21
6	94.91	167.75
7	104.83	166.49
8	114.77	165.42
9	124.73	164.56
10	134.71	163.89
11	144.70	163.42
12	154.70	163.15
13	164.70	163.08
14	174.69	163.20
15	184.69	163.53
16	194.68	164.05
17	204.65	164.78
18	214.61	165.70
19	224.54	166.82
20	234.46	168.13
21	244.34	169.64
22	254.19	171.35
23	264.01	173.26
24	273.79	175.36
25	283.52	177.65
26	293.21	180.14
27	302.84	182.82
28	312.42	185.69
29	321.94	188.74
30	331.40	191.99
31	340.79	195.43
32	350.11	199.05
33	359.36	202.86
34	368.53	206.85
35	377.62	211.02
36	386.62	215.37
37	395.54	219.90
38	404.36	224.60
39	413.09	229.48
40	421.72	234.53
41	430.25	239.76
42	438.67	245.15
43	446.98	250.71
44	455.18	256.43
45	463.27	262.31
46	471.24	268.35
47	479.08	274.56
48	486.80	280.91
49	494.40	287.42
50	501.86	294.08
51	509.19	300.88
52	516.38	307.83
53	523.43	314.92
54	526.37	318.00

Circle Center At X = 163.3 ; Y = 665.9 and Radius, 502.8

*** 3.075 ***

Failure Surface Specified By 58 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	32.63	177.00
2	42.26	174.31
3	51.94	171.81
4	61.67	169.49
5	71.45	167.37
6	81.26	165.44
7	91.11	163.71
8	100.99	162.16
9	110.90	160.81
10	120.83	159.66
11	130.78	158.70
12	140.75	157.93
13	150.74	157.36
14	160.73	156.99
15	170.73	156.81
16	180.73	156.83
17	190.73	157.04
18	200.72	157.45
19	210.70	158.06
20	220.67	158.86
21	230.62	159.85
22	240.55	161.04
23	250.45	162.43
24	260.32	164.01
25	270.17	165.78
26	279.97	167.74
27	289.74	169.90
28	299.46	172.25
29	309.13	174.78
30	318.75	177.51
31	328.32	180.42
32	337.82	183.52
33	347.27	186.81
34	356.65	190.28
35	365.96	193.94
36	375.19	197.77
37	384.35	201.79
38	393.43	205.98
39	402.42	210.35
40	411.33	214.90
41	420.14	219.62
42	428.87	224.51
43	437.49	229.57
44	446.01	234.80
45	454.43	240.20
46	462.74	245.76
47	470.94	251.48
48	479.03	257.36
49	487.00	263.40
50	494.85	269.59
51	502.58	275.94
52	510.18	282.44
53	517.66	289.08
54	525.00	295.87
55	532.21	302.80
56	539.28	309.87
57	546.21	317.08
58	547.06	318.00

Circle Center At X = 174.8 ; Y = 667.2 and Radius, 510.4

*** 3.076 ***

1

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                 Y           A       X       I       S           F       T

                .00     71.88    143.75    215.63    287.50    359.38
  X       .00 +---------+---------+----*----+---------+---------+
              -
              -
              -                         42
              -                       ..21
              -                      ..41*
        71.88 +                    ....16..
              -                   ....417..
              -                  .....21...
              -                 ......21....
              -                 ......16....
              -                .......17....
  A    143.75 +               .......417.....
              -               .......219.....
              -              ........219......
              -              ........219......  *
              -              ........219......
              -             .........219.......
  X    215.63 +             ..........16.......
              -             ..........16........
              -             ..........219.......
              -             ..........219.......
              -             ..........319........    *
              -             ...........16........
  I    287.50 +             ...........219........
              -             ...........416........
              -              ............219........
              -              .............16........
              -              .............319........
              -               .............219.......
  S    359.38 +               .............019........
              -                ............411.......
              -                 .............319.......
              -                 ..............416......
              -                   ...........0311......
              -                   ............8219......
       431.25 +                    ............0411.....
              -                     ...........8321....
              -                      ...........08311...
              -                       ...........04311...
              -                         ..........8421..
              -                          ..........84411..
  F    503.13 +                            .........0843121
              -                              ........085432
              -                                 .......084*
              -                                    ......07
              -                                         ..0
              -
  T    575.00 +                                          . *
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** PCSTABL5M **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer's Method of Slices

Run Date:	1/3/96
Time of Run:	5:00
Run By:	HUSK
Input Data Filename:	STATRUNF.DAT
Output Filename:	STATRUNF.OUT
Plotted Output Filename:	STATRUNF.PLT

PROBLEM DESCRIPTION Summit County Landfill - Run F - Psuedo-Static (flatten toe of slope)

BOUNDARY COORDINATES

5 Top Boundaries
5 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	177.00	55.00	177.00	1
2	55.00	177.00	185.00	220.00	1
3	185.00	220.00	265.00	260.00	1
4	265.00	260.00	525.00	318.00	1
5	525.00	318.00	575.00	318.00	1

1

ISOTROPIC SOIL PARAMETERS

1 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	110.0	130.0	1500.0	29.0	.00	.0	1

A Horizontal Earthquake Loading Coefficient
Of .300 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of .000 Has Been Assigned

Cavitation Pressure = .0 psf

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

300 Trial Surfaces Have Been Generated.

15 Surfaces Initiate From Each Of 20 Points Equally Spaced Along The Ground Surface Between X = 30.00 ft.
and X = 80.00 ft.

Each Surface Terminates Between X = 500.00 ft.
and X = 550.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 25.00 ft.

10.00 ft. Line Segments Define Each Trial Failure Surface.

1

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 56 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	51.05	177.00
2	60.73	174.50
3	70.46	172.19
4	80.24	170.07
5	90.05	168.14
6	99.90	166.41
7	109.78	164.88
8	119.69	163.54
9	129.63	162.40
10	139.58	161.45
11	149.55	160.71
12	159.54	160.16
13	169.53	159.80
14	179.53	159.65
15	189.53	159.69
16	199.53	159.93
17	209.52	160.37
18	219.50	161.01
19	229.46	161.85
20	239.41	162.88
21	249.33	164.11
22	259.23	165.53
23	269.10	167.15

24	278.93	168.97
25	288.73	170.98
26	298.48	173.18
27	308.19	175.58
28	317.85	178.17
29	327.46	180.94
30	337.01	183.91
31	346.49	187.07
32	355.92	190.41
33	365.27	193.94
34	374.56	197.66
35	383.77	201.56
36	392.90	205.64
37	401.95	209.90
38	410.91	214.33
39	419.78	218.95
40	428.56	223.74
41	437.24	228.70
42	445.82	233.83
43	454.30	239.13
44	462.67	244.60
45	470.94	250.24
46	479.08	256.03
47	487.12	261.99
48	495.03	268.10
49	502.82	274.37
50	510.49	280.79
51	518.02	287.37
52	525.43	294.09
53	532.70	300.95
54	539.83	307.96
55	546.82	315.11
56	549.54	318.00

Circle Center At X = 182.3 ; Y = 664.6 and Radius, 504.9

*** 1.462 ***

Individual data on the 59 slices

Slice No.	Width Ft(m)	Weight Lbs(kg)	Water Force Top Lbs(kg)	Water Force Bot Lbs(kg)	Tie Force Norm Lbs(kg)	Tie Force Tan Lbs(kg)	Earthquake Force Hor Lbs(kg)	Earthquake Force Ver Lbs(kg)	Surcharge Load Lbs(kg)
1	3.9	221.6	.0	.0	.0	.0	66.5	.0	.0
2	5.7	1709.8	.0	.0	.0	.0	513.0	.0	.0
3	9.7	7668.3	.0	.0	.0	.0	2300.5	.0	.0
4	9.8	13551.3	.0	.0	.0	.0	4065.4	.0	.0
5	9.8	19285.3	.0	.0	.0	.0	5785.6	.0	.0
6	9.8	24859.0	.0	.0	.0	.0	7457.7	.0	.0
7	9.9	30261.5	.0	.0	.0	.0	9078.5	.0	.0
8	9.9	35482.6	.0	.0	.0	.0	10644.8	.0	.0
9	9.9	40512.4	.0	.0	.0	.0	12153.7	.0	.0
10	10.0	45341.4	.0	.0	.0	.0	13602.4	.0	.0
11	10.0	49961.3	.0	.0	.0	.0	14988.4	.0	.0
12	10.0	54363.4	.0	.0	.0	.0	16309.0	.0	.0
13	10.0	58540.3	.0	.0	.0	.0	17562.1	.0	.0
14	10.0	62485.0	.0	.0	.0	.0	18745.5	.0	.0
15	5.5	35760.3	.0	.0	.0	.0	10728.1	.0	.0
16	4.5	30621.6	.0	.0	.0	.0	9186.5	.0	.0
17	10.0	71425.4	.0	.0	.0	.0	21427.6	.0	.0

18	10.0	76494.0	.0	.0	.0	.0	22948.2	.0	.0
19	10.0	81301.9	.0	.0	.0	.0	24390.6	.0	.0
20	10.0	85841.9	.0	.0	.0	.0	25752.6	.0	.0
21	9.9	90108.0	.0	.0	.0	.0	27032.4	.0	.0
22	9.9	94094.4	.0	.0	.0	.0	28228.3	.0	.0
23	9.9	97796.1	.0	.0	.0	.0	29338.8	.0	.0
24	5.8	58731.9	.0	.0	.0	.0	17619.6	.0	.0
25	4.1	42221.2	.0	.0	.0	.0	12666.4	.0	.0
26	9.8	101628.6	.0	.0	.0	.0	30488.6	.0	.0
27	9.8	101535.2	.0	.0	.0	.0	30460.6	.0	.0
28	9.8	101181.9	.0	.0	.0	.0	30354.6	.0	.0
29	9.7	100571.3	.0	.0	.0	.0	30171.4	.0	.0
30	9.7	99707.4	.0	.0	.0	.0	29912.2	.0	.0
31	9.6	98594.0	.0	.0	.0	.0	29578.2	.0	.0
32	9.5	97235.6	.0	.0	.0	.0	29170.7	.0	.0
33	9.5	95637.7	.0	.0	.0	.0	28691.3	.0	.0
34	9.4	93806.0	.0	.0	.0	.0	28141.8	.0	.0
35	9.4	91746.6	.0	.0	.0	.0	27524.0	.0	.0
36	9.3	89467.2	.0	.0	.0	.0	26840.2	.0	.0
37	9.2	86974.5	.0	.0	.0	.0	26092.4	.0	.0
38	9.1	84277.1	.0	.0	.0	.0	25283.1	.0	.0
39	9.0	81383.1	.0	.0	.0	.0	24414.9	.0	.0
40	9.0	78301.8	.0	.0	.0	.0	23490.5	.0	.0
41	8.9	75043.1	.0	.0	.0	.0	22512.9	.0	.0
42	8.8	71616.4	.0	.0	.0	.0	21484.9	.0	.0
43	8.7	68032.4	.0	.0	.0	.0	20409.7	.0	.0
44	8.6	64302.1	.0	.0	.0	.0	19290.6	.0	.0
45	8.5	60436.6	.0	.0	.0	.0	18131.0	.0	.0
46	8.4	56448.0	.0	.0	.0	.0	16934.4	.0	.0
47	8.3	52348.1	.0	.0	.0	.0	15704.4	.0	.0
48	8.1	48149.4	.0	.0	.0	.0	14444.8	.0	.0
49	8.0	43864.7	.0	.0	.0	.0	13159.4	.0	.0
50	7.9	39507.0	.0	.0	.0	.0	11852.1	.0	.0
51	7.8	35090.0	.0	.0	.0	.0	10527.0	.0	.0
52	7.7	30626.8	.0	.0	.0	.0	9188.0	.0	.0
53	7.5	26131.8	.0	.0	.0	.0	7839.5	.0	.0
54	7.0	20484.1	.0	.0	.0	.0	6145.2	.0	.0
55	.4	1132.3	.0	.0	.0	.0	339.7	.0	.0
56	7.3	16377.2	.0	.0	.0	.0	4913.2	.0	.0
57	7.1	10624.5	.0	.0	.0	.0	3187.4	.0	.0
58	7.0	4970.9	.0	.0	.0	.0	1491.3	.0	.0
59	2.7	431.3	.0	.0	.0	.0	129.4	.0	.0

Failure Surface Specified By 57 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	45.79	177.00
2	55.44	174.38
3	65.14	171.95
4	74.89	169.71
5	84.68	167.66
6	94.50	165.82
7	104.37	164.16
8	114.26	162.71
9	124.18	161.45
10	134.12	160.39
11	144.09	159.53
12	154.06	158.87
13	164.05	158.40
14	174.05	158.13
15	184.05	158.07
16	194.05	158.20
17	204.04	158.53

18	214.03	159.06
19	224.00	159.79
20	233.96	160.72
21	243.90	161.84
22	253.81	163.16
23	263.69	164.68
24	273.54	166.40
25	283.36	168.31
26	293.13	170.42
27	302.87	172.72
28	312.55	175.21
29	322.18	177.90
30	331.76	180.78
31	341.28	183.84
32	350.73	187.10
33	360.12	190.54
34	369.44	194.17
35	378.68	197.99
36	387.85	201.99
37	396.93	206.17
38	405.93	210.53
39	414.84	215.06
40	423.66	219.78
41	432.39	224.67
42	441.01	229.73
43	449.53	234.96
44	457.95	240.36
45	466.25	245.93
46	474.45	251.66
47	482.53	257.56
48	490.49	263.61
49	498.32	269.82
50	506.04	276.19
51	513.62	282.70
52	521.07	289.37
53	528.39	296.19
54	535.58	303.14
55	542.62	310.24
56	549.52	317.48
57	549.99	318.00

Circle Center At X = 182.4 ; Y = 660.4 and Radius, 502.4

*** 1.462 ***

1

Failure Surface Specified By 57 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	48.42	177.00
2	58.00	174.11
3	67.63	171.43
4	77.32	168.95
5	87.05	166.67
6	96.84	164.60
7	106.66	162.73
8	116.52	161.07
9	126.41	159.61
10	136.34	158.37

11	146.28	157.33
12	156.25	156.50
13	166.23	155.88
14	176.22	155.47
15	186.22	155.27
16	196.22	155.28
17	206.22	155.50
18	216.21	155.93
19	226.19	156.56
20	236.15	157.41
21	246.09	158.47
22	256.01	159.73
23	265.91	161.20
24	275.76	162.88
25	285.58	164.77
26	295.36	166.86
27	305.10	169.16
28	314.78	171.66
29	324.41	174.36
30	333.98	177.26
31	343.48	180.36
32	352.92	183.67
33	362.29	187.17
34	371.58	190.86
35	380.79	194.75
36	389.92	198.83
37	398.96	203.11
38	407.91	207.57
39	416.77	212.21
40	425.52	217.05
41	434.17	222.06
42	442.72	227.26
43	451.15	232.63
44	459.47	238.18
45	467.67	243.90
46	475.75	249.80
47	483.70	255.86
48	491.53	262.08
49	499.22	268.47
50	506.78	275.02
51	514.20	281.73
52	521.47	288.59
53	528.60	295.60
54	535.58	302.76
55	542.41	310.07
56	549.09	317.51
57	549.50	318.00

Circle Center At X = 190.8 ; Y = 632.0 and Radius, 476.7

*** 1.464 ***

Failure Surface Specified By 58 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	32.63	177.00
2	42.26	174.31
3	51.94	171.81
4	61.67	169.49

5	71.45	167.37
6	81.26	165.44
7	91.11	163.71
8	100.99	162.16
9	110.90	160.81
10	120.83	159.66
11	130.78	158.70
12	140.75	157.93
13	150.74	157.36
14	160.73	156.99
15	170.73	156.81
16	180.73	156.83
17	190.73	157.04
18	200.72	157.45
19	210.70	158.06
20	220.67	158.86
21	230.62	159.85
22	240.55	161.04
23	250.45	162.43
24	260.32	164.01
25	270.17	165.78
26	279.97	167.74
27	289.74	169.90
28	299.46	172.25
29	309.13	174.78
30	318.75	177.51
31	328.32	180.42
32	337.82	183.52
33	347.27	186.81
34	356.65	190.28
35	365.96	193.94
36	375.19	197.77
37	384.35	201.79
38	393.43	205.98
39	402.42	210.35
40	411.33	214.90
41	420.14	219.62
42	428.87	224.51
43	437.49	229.57
44	446.01	234.80
45	454.43	240.20
46	462.74	245.76
47	470.94	251.48
48	479.03	257.36
49	487.00	263.40
50	494.85	269.59
51	502.58	275.94
52	510.18	282.44
53	517.66	289.08
54	525.00	295.87
55	532.21	302.80
56	539.28	309.87
57	546.21	317.08
58	547.06	318.00

Circle Center At X = 174.8 ; Y = 667.2 and Radius, 510.4

*** 1.465 ***

Failure Surface Specified By 55 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	51.05	177.00
2	60.84	174.94
3	70.66	173.06
4	80.51	171.36
5	90.40	169.84
6	100.31	168.50
7	110.24	167.34
8	120.19	166.36
9	130.16	165.56
10	140.14	164.95
11	150.13	164.52
12	160.13	164.27
13	170.13	164.20
14	180.13	164.32
15	190.12	164.62
16	200.11	165.10
17	210.09	165.76
18	220.05	166.61
19	230.00	167.64
20	239.93	168.84
21	249.83	170.23
22	259.71	171.80
23	269.55	173.55
24	279.37	175.48
25	289.14	177.59
26	298.88	179.88
27	308.57	182.34
28	318.21	184.98
29	327.81	187.80
30	337.35	190.79
31	346.84	193.95
32	356.26	197.29
33	365.63	200.80
34	374.93	204.48
35	384.16	208.33
36	393.31	212.34
37	402.40	216.53
38	411.40	220.87
39	420.33	225.38
40	429.17	230.06
41	437.92	234.89
42	446.59	239.88
43	455.16	245.04
44	463.63	250.34
45	472.01	255.80
46	480.29	261.41
47	488.46	267.18
48	496.53	273.09
49	504.49	279.14
50	512.33	285.34
51	520.06	291.69
52	527.68	298.17
53	535.17	304.79
54	542.54	311.55
55	549.33	318.00

Circle Center At X = 168.8 ; Y = 712.0 and Radius, 547.8

*** 1.466 ***

Failure Surface Specified By 56 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	53.68	177.00
2	63.26	174.12
3	72.90	171.44
4	82.59	168.98
5	92.33	166.72
6	102.12	164.67
7	111.94	162.82
8	121.81	161.19
9	131.71	159.78
10	141.64	158.57
11	151.59	157.58
12	161.56	156.80
13	171.54	156.23
14	181.53	155.88
15	191.53	155.74
16	201.53	155.81
17	211.53	156.10
18	221.52	156.60
19	231.49	157.32
20	241.45	158.25
21	251.38	159.39
22	261.29	160.75
23	271.17	162.32
24	281.01	164.09
25	290.81	166.08
26	300.56	168.28
27	310.27	170.69
28	319.92	173.30
29	329.52	176.12
30	339.05	179.14
31	348.51	182.37
32	357.91	185.80
33	367.22	189.43
34	376.46	193.26
35	385.62	197.28
36	394.68	201.50
37	403.66	205.92
38	412.53	210.52
39	421.31	215.31
40	429.98	220.29
41	438.54	225.46
42	446.99	230.81
43	455.33	236.33
44	463.54	242.03
45	471.63	247.91
46	479.60	253.96
47	487.43	260.18
48	495.12	266.57
49	502.68	273.11
50	510.10	279.82
51	517.37	286.69
52	524.49	293.71
53	531.46	300.88
54	538.27	308.20
55	544.93	315.66
56	546.93	318.00

Circle Center At X = 193.0 ; Y = 622.8 and Radius, 467.1

*** 1.466 ***

1

Failure Surface Specified By 57 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	35.26	177.00
2	44.90	174.31
3	54.58	171.82
4	64.31	169.52
5	74.09	167.42
6	83.90	165.51
7	93.76	163.79
8	103.64	162.28
9	113.55	160.96
10	123.49	159.84
11	133.45	158.92
12	143.42	158.19
13	153.41	157.67
14	163.40	157.34
15	173.40	157.22
16	183.40	157.29
17	193.40	157.57
18	203.39	158.04
19	213.36	158.71
20	223.33	159.58
21	233.27	160.65
22	243.19	161.92
23	253.08	163.39
24	262.94	165.05
25	272.77	166.91
26	282.55	168.97
27	292.30	171.22
28	301.99	173.66
29	311.64	176.30
30	321.23	179.13
31	330.76	182.15
32	340.24	185.35
33	349.64	188.75
34	358.98	192.34
35	368.24	196.11
36	377.42	200.06
37	386.53	204.20
38	395.55	208.52
39	404.48	213.01
40	413.32	217.69
41	422.07	222.54
42	430.71	227.56
43	439.26	232.75
44	447.70	238.12
45	456.03	243.65
46	464.25	249.34
47	472.35	255.20
48	480.34	261.22
49	488.20	267.40
50	495.94	273.74
51	503.55	280.22
52	511.03	286.86

53	518.37	293.65
54	525.58	300.58
55	532.65	307.65
56	539.58	314.86
57	542.47	318.00

Circle Center At X = 174.7 ; Y = 658.4 and Radius, 501.1

*** 1.467 ***

Failure Surface Specified By 54 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	53.68	177.00
2	63.38	174.55
3	73.13	172.31
4	82.91	170.26
5	92.74	168.42
6	102.61	166.78
7	112.50	165.35
8	122.43	164.12
9	132.38	163.09
10	142.34	162.27
11	152.32	161.65
12	162.31	161.24
13	172.31	161.04
14	182.31	161.04
15	192.31	161.25
16	202.30	161.66
17	212.28	162.28
18	222.25	163.11
19	232.20	164.14
20	242.12	165.37
21	252.01	166.81
22	261.88	168.45
23	271.71	170.30
24	281.49	172.35
25	291.24	174.60
26	300.93	177.05
27	310.58	179.69
28	320.16	182.54
29	329.69	185.58
30	339.15	188.82
31	348.54	192.26
32	357.86	195.88
33	367.10	199.70
34	376.27	203.71
35	385.34	207.90
36	394.33	212.28
37	403.23	216.85
38	412.03	221.60
39	420.73	226.53
40	429.33	231.63
41	437.82	236.91
42	446.20	242.37
43	454.47	248.00
44	462.62	253.80
45	470.64	259.76
46	478.55	265.89

47	486.32	272.18
48	493.96	278.62
49	501.47	285.23
50	508.84	291.99
51	516.07	298.89
52	523.16	305.95
53	530.10	313.15
54	534.59	318.00

Circle Center At X = 177.2 ; Y = 646.2 and Radius, 485.2

*** 1.469 ***

1

Failure Surface Specified By 55 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	51.05	177.00
2	60.86	175.03
3	70.70	173.24
4	80.57	171.63
5	90.46	170.20
6	100.38	168.95
7	110.33	167.88
8	120.29	166.99
9	130.26	166.28
10	140.25	165.75
11	150.24	165.40
12	160.24	165.24
13	170.24	165.26
14	180.24	165.45
15	190.23	165.83
16	200.22	166.40
17	210.19	167.14
18	220.14	168.06
19	230.08	169.17
20	240.00	170.45
21	249.89	171.92
22	259.76	173.56
23	269.59	175.38
24	279.39	177.38
25	289.15	179.56
26	298.87	181.92
27	308.54	184.45
28	318.17	187.16
29	327.74	190.04
30	337.26	193.09
31	346.73	196.32
32	356.13	199.72
33	365.47	203.29
34	374.75	207.03
35	383.96	210.93
36	393.09	215.00
37	402.15	219.24
38	411.13	223.64
39	420.02	228.21
40	428.84	232.93
41	437.56	237.82
42	446.20	242.86

43	454.74	248.06
44	463.19	253.41
45	471.54	258.91
46	479.79	264.57
47	487.93	270.37
48	495.96	276.32
49	503.89	282.42
50	511.71	288.66
51	519.41	295.04
52	526.99	301.56
53	534.45	308.21
54	541.80	315.00
55	544.92	318.00

Circle Center At X = 164.3 ; Y = 715.8 and Radius, 550.6

*** 1.469 ***

Failure Surface Specified By 58 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	43.16	177.00
2	52.60	173.71
3	62.12	170.64
4	71.70	167.77
5	81.34	165.12
6	91.04	162.67
7	100.79	160.45
8	110.58	158.43
9	120.42	156.64
10	130.29	155.06
11	140.20	153.69
12	150.13	152.55
13	160.09	151.63
14	170.07	150.92
15	180.05	150.43
16	190.05	150.17
17	200.05	150.12
18	210.05	150.30
19	220.04	150.69
20	230.02	151.31
21	239.99	152.14
22	249.93	153.20
23	259.85	154.47
24	269.74	155.96
25	279.59	157.67
26	289.40	159.59
27	299.17	161.73
28	308.89	164.08
29	318.56	166.65
30	328.16	169.43
31	337.71	172.42
32	347.18	175.62
33	356.58	179.03
34	365.91	182.64
35	375.15	186.46
36	384.30	190.48
37	393.37	194.70
38	402.34	199.12

39	411.21	203.74
40	419.98	208.55
41	428.64	213.55
42	437.18	218.74
43	445.61	224.12
44	453.92	229.68
45	462.11	235.43
46	470.17	241.35
47	478.09	247.45
48	485.88	253.72
49	493.53	260.17
50	501.03	266.77
51	508.39	273.55
52	515.60	280.48
53	522.65	287.57
54	529.54	294.81
55	536.28	302.21
56	542.85	309.75
57	549.25	317.43
58	549.70	318.00

Circle Center At X = 197.1 ; Y = 604.3 and Radius, 454.2

*** 1.471 ***

1

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           Y            A     X     I     S            F     T

             .00     71.88    143.75    215.63    287.50    359.38

X        .00 +---------+---------+----*----+---------+---------+
             -
             -
             -                       .4
             -                     ..41
             -                    ...1*
      71.88 +                  ....41..
             -                 ....21..
             -                .....015..
             -               ......41....
             -               ......21....
             -              .......21...
A    143.75 +             ........015.....
             -             ........015.....
             -            .........015......
             -            .........015......  *
             -            .........015......
             -           ..........015.......
X    215.63 +           ..........015.......
             -           .........0219.......
             -           .........0219.......
             -           .........0315.......
             -           .........0315........   *
             -           ..........0219.......
I    287.50 +           ..........0215........
             -           ...........315........
             -            ..........0159........
             -            ..........0315........
             -             ..........0215........
             -             ..........0315........
S    359.38 +             ...........0119........
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                 -          ..........06219.......
                 -           ...........315........
                 -           ...........0315.......
                 -            ..........0115.......
                 -            ...........0128.......
       431.25 +             ............315.......
                 -              ..........6118.....
                 -               ..........3158.....
                 -                ..........0115.....
                 -                 .........0218....
                 -                  .........01148....
F      503.13 +                   ........31588...
                 -                    ........1158..
                 -                      ......3117*
                 -                        .....216
                 -                             ..1
                 -
T      575.00 +                                 *
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MODIFIED BERGGREN SOLUTION

--- Summary ---

Weather data is from: Ely, Nevada

Design Freezing Index (AIR) = 1210 F-days
Design Freezing Index (SURFACE) = 605 F-days
Mean Annual Temperature = 44.3 Degrees F
Length of Freezing Season = 113 Days

LAYER #: TYPE	LAYER THICK. (ins)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	HEAT CAP.	THERMAL COND.	LATENT HEAT of FUSION	FREEZING IND: DISTRIBUTIOI Each Layer	Accur
1: Fine	24.0	24	93	32.55	0.89	3214.1	499	49:
2: Fine	2.5	24	93	32.55	0.89	3214.1	108	607

End of Frost Penetration

TOTAL FROST PENETRATION = 26.5 inches

MODIFIED BERGGREN SOLUTION

--- Summary ---

Weather data is from: Ely, Nevada

Design Freezing Index (AIR) = 1210 F-days
Design Freezing Index (SURFACE) = 1210 F-days
Mean Annual Temperature = 44.3 Degrees F
Length of Freezing Season = 113 Days

LAYER #: TYPE	LAYER THICK. (ins)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	HEAT CAP.	THERMAL COND.	LATENT HEAT of FUSION	FREEZING IND DISTRIBUTIO Each Layer	Accu
1: Snow	6.0	0	15	9.50	0.02	0.0	0	
2: Fine	2.5	24	93	32.55	0.89	3214.1	1204	120

End of Frost Penetration

** Berggren calculations could not converge Design Surface Freezing Index

TOTAL FROST PENETRATION = 8.5 inches

MODIFIED BERGGREN SOLUTION

--- Summary ---

Weather data is from: Ely, Nevada

Design Freezing Index (AIR) = 1210 F-days
Design Freezing Index (SURFACE) = 605 F-days
Mean Annual Temperature = 44.3 Degrees F
Length of Freezing Season = 113 Days

LAYER #: TYPE	LAYER THICK. (ins)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	HEAT CAP.	THERMAL COND.	LATENT HEAT of FUSION	FREEZING IND. DISTRIBUTIO[illegible] Each Layer	Accu[illegible]
1: Fine	24.0	15	110	31.08	0.96	2376.0	367	36[illegible]
2: Fine	7.0	15	110	31.08	0.96	2376.0	246	61[illegible]

End of Frost Penetration

TOTAL FROST PENETRATION = 31.0 inches

MODIFIED BERGGREN SOLUTION

--- Summary ---

Weather data is from: Ely, Nevada

Design Freezing Index (AIR) = 1210 F-days
Design Freezing Index (SURFACE) = 1210 F-days
Mean Annual Temperature = 44.3 Degrees F
Length of Freezing Season = 113 Days

LAYER #: TYPE	LAYER THICK. (ins)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	HEAT CAP.	THERMAL COND.	LATENT HEAT of FUSION	FREEZING INDE[X] DISTRIBUTION Each Layer	Accum
1: Snow	6.0	0	15	9.50	0.02	0.0	0	0
2: Fine	3.1	15	110	31.08	0.96	2376.0	1206	1206

End of Frost Penetration

** Berggren calculations could not converge Design Surface Freezing Index

TOTAL FROST PENETRATION = 9.1 inches

HYDROLOGY CALCULATIONS

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

STORM Output

From STORM → Max flow = 7.6 cfs (25-yr, 24-hr event)
Total vol. = 0.60 acre-feet

(Output is shown on attached sheets)

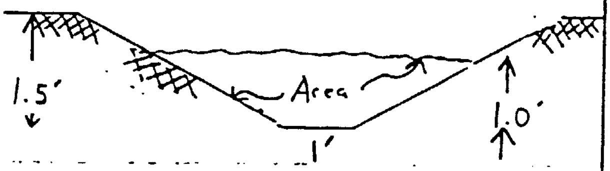
Size Earthen Channel

Min. slope = 1%
Manning n = 0.04
b = ? , Q = 7.6 cfs
m = 2:1

$$* \; Q = \frac{1.49}{n} \frac{A^{5/3}}{P^{2/3}} S_o^{1/2}$$

n = Manning n
A = Area of water
P = Wetted Perimeter
S_o = Slope of channel

Given Q → find depth (y)
For b = 1′ → y = 1.0′



For b = 0′ → y = 1.23

Use Channel with b = 1′
depth = 1½′
m = 2:1

Calculate Velocities

* If velocities greater than 6.0 ft/s → erosion protection

Given y, from above, calculate velocity (v)

Slope (%)	b = 1′	b = 0′
1	2.5 ft/s	
2	3.5	
3	4.3	
5	5.6 ft/s	5.6 ft/s
6	6.1	

$$* \; V = \frac{1.49}{n} R_h^{2/3} S_o^{1/2}$$

R_h = Hydraulic Radius

*if slope greater than 5% → use riprap

Slopes of the riprap-zoned channel range from 5% to 50%

SLOPE	% OF CHANNEL
< 10%	68%
11 - 15%	17%
16 - 20%	10%
21 - 25%	3%
> 25%	2%

The following pages show the anticipated velocities with different slopes for the given channel design. The average slope is 11%, which would result in a velocity of 6.09 fps. To be conservative an average velocity of approximately 8.5 fps was used to size the riprap. Using the attached nomograph, the required riprap would have a D_{50} of 0.5'.

therefore, the specification for riprap is as follows:

Diameter	% Passing by weight
12"	100%
6"	40 - 60%
2"	< 5%

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name:

Description:

Solve For Depth

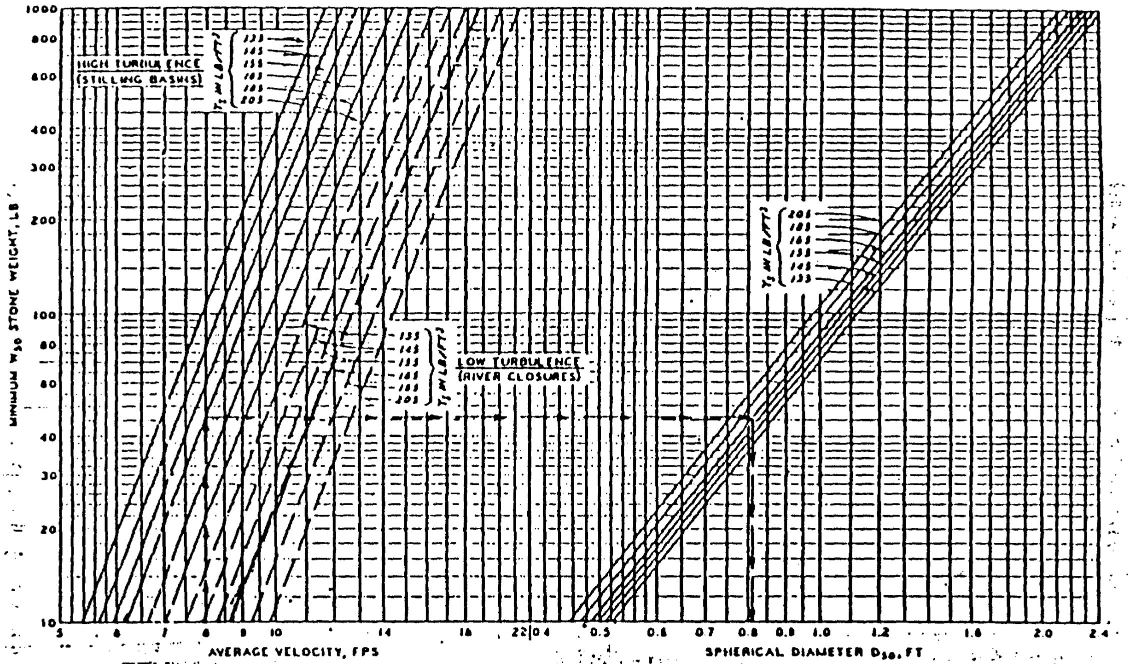
Given Constant Data;

Bottom Width.......	1.00
Z-Left.............	2.00
Z-Right............	2.00
Mannings 'n'.......	0.040
Channel Discharge..	7.60

Variable Input Data	Minimum	Maximum	Increment By
Channel Slope	0.0500	0.5000	0.0200

Bottom Width ft	Z-Left (H:V)	Z-Right (H:V)	Mannings 'n'	VARIABLE Channel Slope ft/ft	COMPUTED Channel Depth ft	Channel Discharge cfs	COMPUTED Velocity fps
1.00	2.00	2.00	0.040	0.0500	0.70	7.60	4.55
1.00	2.00	2.00	0.040	0.0700	0.64	7.60	5.16
1.00	2.00	2.00	0.040	0.0900	0.61	7.60	5.66
1.00	2.00	2.00	0.040	0.1100	0.58	7.60	6.09
1.00	2.00	2.00	0.040	0.1300	0.56	7.60	6.48
1.00	2.00	2.00	0.040	0.1500	0.54	7.60	6.83
1.00	2.00	2.00	0.040	0.1700	0.52	7.60	7.15
1.00	2.00	2.00	0.040	0.1900	0.51	7.60	7.45
1.00	2.00	2.00	0.040	0.2100	0.49	7.60	7.73
1.00	2.00	2.00	0.040	0.2300	0.48	7.60	8.00
1.00	2.00	2.00	0.040	0.2500	0.47	7.60	8.24
1.00	2.00	2.00	0.040	0.2700	0.46	7.60	8.48
1.00	2.00	2.00	0.040	0.2900	0.46	7.60	8.71
1.00	2.00	2.00	0.040	0.3100	0.45	7.60	8.92
1.00	2.00	2.00	0.040	0.3300	0.44	7.60	9.13
1.00	2.00	2.00	0.040	0.3500	0.44	7.60	9.33
1.00	2.00	2.00	0.040	0.3700	0.43	7.60	9.52
1.00	2.00	2.00	0.040	0.3900	0.42	7.60	9.70
1.00	2.00	2.00	0.040	0.4100	0.42	7.60	9.88
1.00	2.00	2.00	0.040	0.4300	0.41	7.60	10.06
1.00	2.00	2.00	0.040	0.4500	0.41	7.60	10.22
1.00	2.00	2.00	0.040	0.4700	0.40	7.60	10.39
1.00	2.00	2.00	0.040	0.4900	0.40	7.60	10.55
1.00	2.00	2.00	0.040	0.5100	0.40	7.60	10.70

INCL 1



BASIC EQUATIONS

$$V = C\left[2g\left(\frac{\gamma_s - \gamma_w}{\gamma_w}\right)\right]^{1/2}(D_{50})^{1/2}$$

$$D_{50} = \left(\frac{6W_{50}}{\pi \gamma_s}\right)^{1/3}$$

WHERE:
- V = VELOCITY, FPS
- γ_s = SPECIFIC STONE WEIGHT, LB/FT^3
- γ_w = SPECIFIC WEIGHT OF WATER, 62.5 LB/FT^3
- W_{50} = WEIGHT OF STONE. SUBSCRIPT DENOTES PERCENT OF TOTAL WEIGHT OF MATERIAL CONTAINING STONE OF LESS WEIGHT.
- D_{50} = SPHERICAL DIAMETER OF STONE HAVING THE SAME WEIGHT AS W_{50}
- C = ISBASH CONSTANT (0.86 FOR HIGH TURBULENCE LEVEL FLOW AND 1.20 FOR LOW TURBULENCE LEVEL FLOW)
- g = ACCELERATION OF GRAVITY, FT/SEC^2

STONE STABILITY
VELOCITY VS STONE DIAMETER

HYDRAULIC DESIGN CHART 712-1
(SHEET 1 OF 2)

REV 6-54, 9-70 WES 6-57

Purpose: Calculate site runon from area west of the current landfill.

Given: Drainage area west of site sheet flows onto western site boundary
Area (drainage) is 20 acres (Existing diversion swale)
Vegetation is fair-condition sagebrush
Soil is 90% HmG, loam, group "C" (1)
10% AmD, silty loam, group "C"
CN is 67 (BOR, "Design of Small Dams", 1977, Table A-4, pg 535)
Precip. = 2.5" (25-yr, 24-hr), 3.0 (100-yr, 24-hr) (2)

(1) Bulletin 495, 1977, SCS
(2) NOAA Atlas 2, "Precipitation Freq. of Western U.S.", 1973

STORM Input

Area = 20 acres, 0.0313 mi^2
CN = 67 *
Precip = 2.5" (25-yr, 24-hr)
t_c → calculate
$L = 0.27$
$L_c = 0.10$
$S = 1550$ ft/mile

$$t_p = 1.2\left[\frac{(0.27)(0.10)}{\sqrt{1550}}\right]^{.38} = 0.075 \text{ hours } (4.5 \text{ min})$$

$$t_c = 1.667\,(t_p) = \underline{0.125 \text{ hours}} \; (7.5 \text{ min})$$

Size Culvert

There will be one culvert that will pass under the road that is located south of the waste cell.

Assume: Flow = 5 cfs (2/3 of total of 7.6 cfs)
Manning n = 0.015
slope = 1%

12" CMP → Q = 3.1 cfs max

18" CMP → Q = 9.1 cfs max

Use a 18" CMP

3 MILE LANDFILL - RUNON - 25 YEAR, 24 HOUR EVENT
STORM HYDROGRAPH RAIN = 2.500 DURATION = 24.0 RUNOFF = .356
STORM DISTRIBUTION IS SCS 24-HR
CURVE NUMBER METHOD CN =67.0

TIME (HOURS)	RAINFALL (INCHES)	NET RAIN (INCHES)	DISCHARGE (CFS)
.000	.0000	.0000	.00
.100	.0030	.0000	.00
.200	.0030	.0000	.00
zero			zero
11.600	.1040	.0000	.00
11.700	.1040	.0000	.00
11.800	.1900	.0029	.00
11.900	.2760	.0267	.32
12.000	.2760	.0512	3.20
12.100	.0360	.0083	7.64
12.200	.0360	.0087	4.91
12.300	.0360	.0090	2.61
12.400	.0360	.0093	2.06
12.500	.0360	.0097	1.87
12.600	.0185	.0051	1.94
12.700	.0185	.0052	1.45
12.800	.0185	.0053	1.16
12.900	.0185	.0054	1.10
13.000	.0185	.0054	1.08
13.100	.0135	.0040	1.10
13.200	.0135	.0041	.95
13.300	.0135	.0041	.86
13.400	.0135	.0041	.84
13.500	.0135	.0042	.84
13.600	.0105	.0033	.85
13.700	.0105	.0033	.75
13.800	.0105	.0033	.70
13.900	.0105	.0034	.69
14.000	.0105	.0034	.68
14.100	.0075	.0024	.69
14.200	.0075	.0024	.58
14.300	.0075	.0025	.52
14.400	.0075	.0025	.51
14.500	.0075	.0025	.50
14.600	.0075	.0025	.51
14.700	.0075	.0025	.51
14.800	.0075	.0025	.51
14.900	.0075	.0025	.51
15.000	.0075	.0025	.52
15.100	.0075	.0026	.52
15.200	.0075	.0026	.52
15.300	.0075	.0026	.52
15.400	.0075	.0026	.53
15.500	.0075	.0026	.53
15.600	.0075	.0026	.53

15.700	.0075	.0026	.53
15.800	.0075	.0026	.54
15.900	.0075	.0027	.54
16.000	.0075	.0027	.54
16.100	.0045	.0016	.54
16.200	.0045	.0016	.43
16.300	.0045	.0016	.35
16.400	.0045	.0016	.34
16.500	.0045	.0016	.33
16.600	.0045	.0016	.33
16.700	.0045	.0016	.33
16.800	.0045	.0016	.33
16.900	.0045	.0016	.33
17.000	.0045	.0016	.33
17.100	.0045	.0016	.34
17.200	.0045	.0017	.34
17.300	.0045	.0017	.34
17.400	.0045	.0017	.34
17.500	.0045	.0017	.34
17.600	.0045	.0017	.34
17.700	.0045	.0017	.34
17.800	.0045	.0017	.34
17.900	.0045	.0017	.34
18.000	.0045	.0017	.34
18.100	.0045	.0017	.34
18.200	.0045	.0017	.34
18.300	.0045	.0017	.35
18.400	.0045	.0017	.35
18.500	.0045	.0017	.35
18.600	.0045	.0017	.35
18.700	.0045	.0017	.35
18.800	.0045	.0017	.35
18.900	.0045	.0017	.35
19.000	.0045	.0017	.35
19.100	.0045	.0017	.35
19.200	.0045	.0017	.35
19.300	.0045	.0017	.35
19.400	.0045	.0017	.35
19.500	.0045	.0017	.36
19.600	.0045	.0017	.36
19.700	.0045	.0018	.36
19.800	.0045	.0018	.36
19.900	.0045	.0018	.36
20.000	.0045	.0018	.36
20.100	.0030	.0012	.36
20.200	.0030	.0012	.29
20.300	.0030	.0012	.26
20.400	.0030	.0012	.25
20.500	.0030	.0012	.24
20.600	.0030	.0012	.24
20.700	.0030	.0012	.24
20.800	.0030	.0012	.24
20.900	.0030	.0012	.24
21.000	.0030	.0012	.24
21.100	.0030	.0012	.24

21.200	.0030	.0012	.24
21.300	.0030	.0012	.24
21.400	.0030	.0012	.25
21.500	.0030	.0012	.25
21.600	.0030	.0012	.25
21.700	.0030	.0012	.25
21.800	.0030	.0012	.25
21.900	.0030	.0012	.25
22.000	.0030	.0012	.25
22.100	.0030	.0012	.25
22.200	.0030	.0012	.25
22.300	.0030	.0012	.25
22.400	.0030	.0012	.25
22.500	.0030	.0012	.25
22.600	.0030	.0012	.25
22.700	.0030	.0012	.25
22.800	.0030	.0012	.25
22.900	.0030	.0012	.25
23.000	.0030	.0012	.25
23.100	.0030	.0012	.25
23.200	.0030	.0012	.25
23.300	.0030	.0012	.25
23.400	.0030	.0012	.25
23.500	.0030	.0012	.25
23.600	.0030	.0012	.25
23.700	.0030	.0012	.25
23.800	.0030	.0012	.25
23.900	.0030	.0012	.25
24.000	.0030	.0012	.25
24.100	.0000	.0000	.25
24.200	.0000	.0000	.11
24.300	.0000	.0000	.03
24.400	.0000	.0000	.01
24.500	.0000	.0000	.00
TOTALS	2.500	.3563	72.86

STORM HYDROGRAPH VOLUME = .60 ACRE-FEET
MAXIMUN STORM DISCHARGE = 7.64 CFS

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

Purpose: Calculate flow in intermittent stream that skirts the landfill site to the north. This includes flow from all (Except the landfill Area) the drainage area upgradient of the detention pond outlot.

Assume: Storm event is 100-yr, 24-hr storm & 25-yr
Precip. = 3.0" and 2.5"
Vegetation is fair-condition sagebrush
Soil is 40% AmG, loam, group C, CN = 67
20% AmD, silty loam, group C, CN = 67
20% Vhf, gravelly loam, group B, CN = 46
20% UhG, gravelly loam, group B, CN = 46

STORM Input

Area = 200 acres ($0.313\ mi^2$)
CN = .60(67) + .40(46) = 59
Precip. = 3.0" & 2.5"
tc → calculate

L = 0.91
Lc = 0.43
S = 1350 ft/mile

$$t_p = 1.2 \left[\frac{(0.91)(0.43)}{\sqrt{1350}} \right]^{.38} = 0.214\ hr$$

$$t_c = 1.667\ t_p = \underline{0.36\ hr} \quad (22\ min)$$

Storm Output

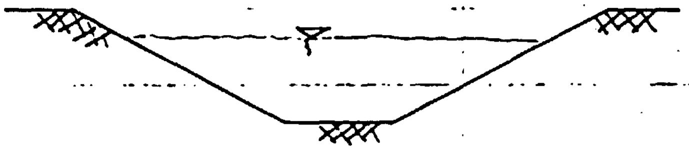
* Using area-weighted CN for entire area
Total storm runoff volume = 5.1 acre-feet
Max discharge = 30 cfs (100 yr storm)
Max discharge = 7.5 cfs (25 yr storm)

* Other Method (25 yr)
120 acres @ CN = 67 → 27 cfs
80 acres @ CN = 46 0.1 cfs
(Don't use area-weighted CN)

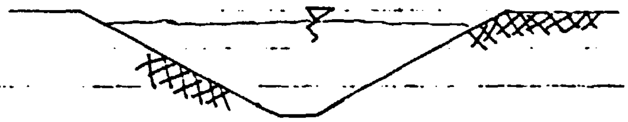
Size Earthen Channel

$Q = 27\ cfs$
Manning $n = 0.04$
$m = 2:1$
slope ranges from 4-15 %

1) $b = 2'$, slope $= 4\%$ → depth $= 1.1'$, velocity $= 5.7\ ft/s$ *

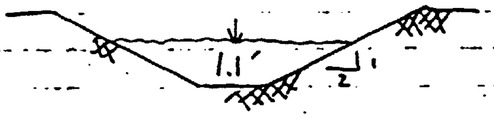


2) $b = 1'$, slope $= 4\%$ → depth $= 1.3'$, velocity $= 5.8\ ft/s$ *



* Riprap would be required in the intermittent stream where there is a slope 4% or greater; prior to where runoff from the landfill enters the stream

Use channel with: $b = 2'$
depth $= 2'$
$m = 2:1$



Size Culvert

Q = 27 cfs
Manning n = 0.015 (CMP)
Slope = 1%
Culverts run under north access road, adjacent to north edge of landfill

24" CMP → Will carry 19.6 cfs flowing full ($A = 3.14\ ft^2$)

30" CMP → Will carry 36 cfs flowing full ($A = 4.91\ ft^2$)

36" CMP → " 58 cfs ($A = 7.07\ ft^2$)

* Install a 36" CMP where needed as culverts under north access road.

(Conservative as this includes drainage areas that discharge into the stream below the CMPs.)

15.600	.0090	.0025	4.90
15.700	.0090	.0025	4.93
15.800	.0090	.0025	4.96
15.900	.0090	.0025	4.99
16.000	.0090	.0025	5.02
16.100	.0054	.0015	5.05
16.200	.0054	.0015	4.92
16.300	.0054	.0015	4.44
16.400	.0054	.0015	3.89
16.500	.0054	.0015	3.52
16.600	.0054	.0015	3.34
16.700	.0054	.0016	3.24
16.800	.0054	.0016	3.19
16.900	.0054	.0016	3.16
17.000	.0054	.0016	3.15
17.100	.0054	.0016	3.15
17.200	.0054	.0016	3.16
17.300	.0054	.0016	3.17
17.400	.0054	.0016	3.18
17.500	.0054	.0016	3.19
17.600	.0054	.0016	3.21
17.700	.0054	.0016	3.22
17.800	.0054	.0016	3.23
17.900	.0054	.0016	3.24
18.000	.0054	.0016	3.25
18.100	.0054	.0016	3.26
18.200	.0054	.0016	3.27
18.300	.0054	.0016	3.28
18.400	.0054	.0016	3.29
18.500	.0054	.0016	3.30
18.600	.0054	.0016	3.31
18.700	.0054	.0017	3.31
18.800	.0054	.0017	3.32
18.900	.0054	.0017	3.33
19.000	.0054	.0017	3.34
19.100	.0054	.0017	3.35
19.200	.0054	.0017	3.36
19.300	.0054	.0017	3.37
19.400	.0054	.0017	3.38
19.500	.0054	.0017	3.39
19.600	.0054	.0017	3.40
19.700	.0054	.0017	3.41
19.800	.0054	.0017	3.42
19.900	.0054	.0017	3.43
20.000	.0054	.0017	3.44
20.100	.0036	.0011	3.45
20.200	.0036	.0011	3.37
20.300	.0036	.0012	3.09
20.400	.0036	.0012	2.78
20.500	.0036	.0012	2.57
20.600	.0036	.0012	2.46
20.700	.0036	.0012	2.40
20.800	.0036	.0012	2.37
20.900	.0036	.0012	2.36
21.000	.0036	.0012	2.35

21.100	.0036	.0012	2.35
21.200	.0036	.0012	2.35
21.300	.0036	.0012	2.36
21.400	.0036	.0012	2.36
21.500	.0036	.0012	2.37
21.600	.0036	.0012	2.37
21.700	.0036	.0012	2.38
21.800	.0036	.0012	2.38
21.900	.0036	.0012	2.38
22.000	.0036	.0012	2.39
22.100	.0036	.0012	2.39
22.200	.0036	.0012	2.40
22.300	.0036	.0012	2.40
22.400	.0036	.0012	2.40
22.500	.0036	.0012	2.41
22.600	.0036	.0012	2.41
22.700	.0036	.0012	2.42
22.800	.0036	.0012	2.42
22.900	.0036	.0012	2.42
23.000	.0036	.0012	2.43
23.100	.0036	.0012	2.43
23.200	.0036	.0012	2.44
23.300	.0036	.0012	2.44
23.400	.0036	.0012	2.45
23.500	.0036	.0012	2.45
23.600	.0036	.0012	2.45
23.700	.0036	.0012	2.46
23.800	.0036	.0012	2.46
23.900	.0036	.0012	2.47
24.000	.0036	.0012	2.47
24.100	.0000	.0000	2.47
24.200	.0000	.0000	2.28
24.300	.0000	.0000	1.67
24.400	.0000	.0000	.99
24.500	.0000	.0000	.52
24.600	.0000	.0000	.28
24.700	.0000	.0000	.15
24.800	.0000	.0000	.08
24.900	.0000	.0000	.03
25.000	.0000	.0000	.01
25.100	.0000	.0036	.00
TOTALS	3.000	.3065	613.63

STORM HYDROGRAPH VOLUME = 5.07 ACRE-FEET
MAXIMUN STORM DISCHARGE = 29.22 CFS , say 30

3 MILE LANDFILL - STREAM - ~~100~~ 25 YEAR, 24 HOUR EVENT
STORM HYDROGRAPH RAIN = 2.500 DURATION = 24.0 RUNOFF = .156
STORM DISTRIBUTION IS SCS 24-HR
CURVE NUMBER METHOD CN =59.0

Area-Weighted CN

TIME (HOURS)	RAINFALL (INCHES)	NET RAIN (INCHES)	DISCHARGE (CFS)
.000	.0000	.0000	.00
.100	.0030	.0000	.00
.200	.0030	.0000	.00
.300	.0030	.0000	.00
.400	.0030	.0000	.00
.500	.0030	.0000	.00
.600	.0030	.0000	.00
11.800	.1900	.0000	.00
11.900	.2760	.0000	.00
12.000	.2760	.0099	.00
12.100	.0360	.0028	1.59
12.200	.0360	.0031	5.41
12.300	.0360	.0034	7.39
12.400	.0360	.0038	7.47
12.500	.0360	.0041	7.05
12.600	.0185	.0022	7.25
12.700	.0185	.0023	7.29
12.800	.0185	.0024	6.72
12.900	.0185	.0025	5.91
13.000	.0185	.0025	5.35
13.100	.0135	.0019	5.14
13.200	.0135	.0019	5.00
13.300	.0135	.0020	4.70
13.400	.0135	.0020	4.38
13.500	.0135	.0021	4.18
13.600	.0105	.0016	4.13
13.700	.0105	.0017	4.07
24.600	.0000	.0000	.18
24.700	.0000	.0000	.10
24.800	.0000	.0000	.05
24.900	.0000	.0000	.02
25.000	.0000	.0000	.01
25.100	.0000	.0030	.00
TOTALS	2.500	.1559	309.80

STORM HYDROGRAPH VOLUME = 2.56 ACRE-FEET
MAXIMUN STORM DISCHARGE = ≃7.47 CFS

3 MILE LANDFILL - STREAM - ~~100~~ 25 YEAR, 24 HOUR EVENT
STORM HYDROGRAPH RAIN = 2.500 DURATION = 24.0 RUNOFF = .359
STORM DISTRIBUTION IS SCS 24-HR
CURVE NUMBER METHOD CN =67.0

Soil Group C

TIME (HOURS)	RAINFALL (INCHES)	NET RAIN (INCHES)	DISCHARGE (CFS)	
.000	.0000	.0000	.00	
.100	.0030	.0000	.00	
.200	.0030	.0000	.00	
.300	.0030	.0000	.00	
11.700	.1040	.0000	.00	
11.800	.1900	.0029	.00	
11.900	.2760	.0267	.28	50 ft³
12.000	.2760	.0512	3.43	718 ft³
12.100	.0360	.0083	13.88	3834
12.200	.0360	.0087	25.71	10,460
12.300	.0360	.0090	26.88	20,426
12.400	.0360	.0093	21.38	29,113
12.500	.0360	.0097	16.24	35,884
12.600	.0185	.0051	14.05	41,337
12.700	.0185	.0052	12.59	46,132 ft³
12.800	.0185	.0053	10.81	50,344 ft³ accumulated flow at 12.75 hr
12.900	.0185	.0054	8.92	
13.000	.0185	.0054	7.57	
13.100	.0135	.0040	6.98	
13.200	.0135	.0041	6.66	
13.300	.0135	.0041	6.15	
13.400	.0135	.0041	5.63	
13.500	.0135	.0042	5.30	
13.600	.0105	.0033	5.17	
13.700	.0105	.0033	5.04	
24.200	.0000	.0000	1.39	
24.300	.0000	.0000	1.02	
24.400	.0000	.0000	.61	
24.500	.0000	.0000	.32	
24.600	.0000	.0000	.17	
24.700	.0000	.0000	.09	
24.800	.0000	.0000	.05	
24.900	.0000	.0000	.02	
25.000	.0000	.0000	.01	
25.100	.0000	.0030	.00	
TOTALS	2.500	.3593	433.60	

STORM HYDROGRAPH VOLUME = 3.58 ACRE-FEET
MAXIMUN STORM DISCHARGE = 26.88 CFS

3 MILE LANDFILL - STREAM - ~~100~~ 25 YEAR, 24 HOUR EVENT
STORM HYDROGRAPH RAIN = 2.500 DURATION = 24.0 RUNOFF = .005
STORM DISTRIBUTION IS SCS 24-HR
CURVE NUMBER METHOD CN =46.0

Soil Group B

TIME (HOURS)	RAINFALL (INCHES)	NET RAIN (INCHES)	DISCHARGE (CFS)
.000	.0000	.0000	.00
.100	.0030	.0000	.00
.200	.0030	.0000	.00
.300	.0030	.0000	.00
.400	.0030	.0000	.00
19.400	.0045	.0000	.00
19.500	.0045	.0000	.00
19.600	.0045	.0000	.00
19.700	.0045	.0000	.00
19.800	.0045	.0000	.00
19.900	.0045	.0000	.01
20.000	.0045	.0000	.01
20.100	.0030	.0000	.01
20.200	.0030	.0000	.01
20.300	.0030	.0000	.01
20.400	.0030	.0000	.02
20.500	.0030	.0000	.02
20.600	.0030	.0000	.02
20.700	.0030	.0000	.02
20.800	.0030	.0000	.02
20.900	.0030	.0000	.02
21.000	.0030	.0000	.02
21.100	.0030	.0000	.02
21.200	.0030	.0000	.02
21.300	.0030	.0000	.02
21.400	.0030	.0000	.03
21.500	.0030	.0000	.03
21.600	.0030	.0000	.03
21.700	.0030	.0000	.03
21.800	.0030	.0000	.03
21.900	.0030	.0000	.03
22.000	.0030	.0000	.03
22.100	.0030	.0000	.03
22.200	.0030	.0000	.04
22.300	.0030	.0001	.04
22.400	.0030	.0001	.04
22.500	.0030	.0001	.04
22.600	.0030	.0001	.04
22.700	.0030	.0001	.04
22.800	.0030	.0001	.04
22.900	.0030	.0001	.04

1

3 MILE LANDFILL - STREAM - 100 YEAR, 24 HOUR EVENT
STORM HYDROGRAPH RAIN = 2.500 DURATION = 24.0 RUNOFF = .005

STORM DISTRIBUTION IS SCS 24-HR
CURVE NUMBER METHOD CN =46.0

TIME (HOURS)	RAINFALL (INCHES)	NET RAIN (INCHES)	DISCHARGE (CFS)
23.000	.0030	.0001	.05
23.100	.0030	.0001	.05
23.200	.0030	.0001	.05
23.300	.0030	.0001	.05
23.400	.0030	.0001	.05
23.500	.0030	.0001	.05
23.600	.0030	.0001	.05
23.700	.0030	.0001	.05
23.800	.0030	.0001	.05
23.900	.0030	.0001	.06
24.000	.0030	.0001	.06
24.100	.0000	.0000	.06
24.200	.0000	.0000	.05
24.300	.0000	.0000	.04
24.400	.0000	.0000	.02
24.500	.0000	.0000	.01
24.600	.0000	.0000	.01
24.700	.0000	.0000	.00
24.800	.0000	.0000	.00
24.900	.0000	.0000	.00
25.000	.0000	.0000	.00
25.100	.0000	.0030	.00
TOTALS	2.500	.0049	1.58

STORM HYDROGRAPH VOLUME = .01 ACRE-FEET
MAXIMUN STORM DISCHARGE = .06 CFS

Purpose: Calculate flow from tributary intermittent streams that flow under the north dirt access road. Size culverts under road. (and asphalt)

Assume: Largest drainage is 35 acres (worst case drainage)
Manning n = 0.015 (CMP culvert)
Min. slope = 2%
CN for group C, fair sagebrush = 67
" B, " " = 46

STORM Modeling

Area = 35 acres (0.055 mi^2)
CN = 57 (fair condition sagebrush, 1/2 group B+C)
Precip. = 2.5" (25-yr, 24-hr storm)

1st Case

Input

$t_c \rightarrow$ L = 0.34
L_c = 0.14
S = 950

$$t_p = 1.2\left[\frac{(0.34)(0.14)}{\sqrt{950}}\right]^{.38} = 0.10 \text{ hrs } (6 \text{ min.})$$

$$t_c = 1.667\,(0.1) = \underline{0.17} \text{ hrs}$$

Output

Max flow = 1.0 cfs

2nd Case

Area = 10 acres (0.016 mi^2)
CN = 67 (group C), assume $t_c \cong 0$
Precip = 2.5"

Max flow = 4.3 cfs

Design for 5.0 cfs

Size Culverts

Flow = 5.0 cfs
Slope = 1.0%
Manning n = 0.015

12" CMP → if flowing full will carry 3.1 cfs
18" CMP → " " " " " 9.1 cfs

Use a 18" CMP for culverts under north access road except for main channel that runs along base of landfill berm.

3 MILE LANDFILL - CULVERT - 100 YEAR, 24 HOUR EVENT
STORM HYDROGRAPH RAIN = 2.500 DURATION = 24.0 RUNOFF = .115
STORM DISTRIBUTION IS SCS 24-HR
CURVE NUMBER METHOD CN =57.0

TIME (HOURS)	RAINFALL (INCHES)	NET RAIN (INCHES)	DISCHARGE (CFS)
.000	.0000	.0000	.00
.100	.0030	.0000	.00
.200	.0030	.0000	.00
.300	.0030	.0000	.00
12.000	.2760	.0029	.00
12.100	.0360	.0015	.69
12.200	.0360	.0019	.63
12.300	.0360	.0022	.65
12.400	.0360	.0025	.74
12.500	.0360	.0028	.84
12.600	.0185	.0016	.96
12.700	.0185	.0016	.69
12.800	.0185	.0017	.61
12.900	.0185	.0018	.61
13.000	.0185	.0019	.63
13.100	.0135	.0014	.66
13.200	.0135	.0015	.56
13.300	.0135	.0015	.53
24.300	.0000	.0000	.02
24.400	.0000	.0000	.00
24.500	.0000	.0000	.00
TOTALS	2.500	.1151	41.31

STORM HYDROGRAPH VOLUME = .34 ACRE-FEET
MAXIMUN STORM DISCHARGE = .96 CFS

3 MILE LANDFILL - CULVERT - 100 YEAR, 24 HOUR EVENT
STORM HYDROGRAPH RAIN = 2.500 DURATION = 24.0 RUNOFF = .356
STORM DISTRIBUTION IS SCS 24-HR
CURVE NUMBER METHOD CN =67.0

TIME (HOURS)	RAINFALL (INCHES)	NET RAIN (INCHES)	DISCHARGE (CFS)
.000	.0000	.0000	.00
.100	.0030	.0000	.00
.200	.0030	.0000	.00
.300	.0030	.0000	.00
.400	.0030	.0000	.00
.500	.0030	.0000	.00
11.700	.1040	.0000	.00
11.800	.1900	.0029	.00
11.900	.2760	.0267	.20
12.000	.2760	.0512	1.94
12.100	.0360	.0083	4.30
12.200	.0360	.0087	2.13
12.300	.0360	.0090	1.20
12.400	.0360	.0093	.99
12.500	.0360	.0097	.96
12.600	.0185	.0051	1.00
12.700	.0185	.0052	.69
12.800	.0185	.0053	.57
12.900	.0185	.0054	.55
13.000	.0185	.0054	.56
13.100	.0135	.0040	.56
13.200	.0135	.0041	.47
13.300	.0135	.0041	.43
13.400	.0135	.0041	.43
13.500	.0135	.0042	.43
13.600	.0105	.0033	.44
13.700	.0105	.0033	.37
24.300	.0000	.0000	.01
24.400	.0000	.0000	.00
24.500	.0000	.0000	.00
TOTALS	2.500	.3563	37.20

STORM HYDROGRAPH VOLUME = .31 ACRE-FEET
MAXIMUN STORM DISCHARGE = 4.30 CFS

Purpose: Calculate runoff from waste cell permit area.

Assume: Disturbed area = 19 acres (CN = 80)[1] > Drains into cell
Undisturbed area = 4 acres (CN = 67)[2]
Disturbed area = 5 acres (CN = 86)[2] → Drains off cell into drainage (Berm Area)

(1) Assumed value, soil within the waste cell is not compacted and therefore quite pervious even without vegetation.
(2) From Viessman, 1989

Runoff from within cell

Runoff drains near where north access road enters the cell

From STORM Modeling
19 acres (0.03 mi²), CN = 80 (Assumed ~~Viessman, 1989~~)
4 acres (0.0063), CN = 67 (sage brush - fair condition)
both, tc ≅ 0, precip = 2.5"

Max flow = 24 cfs (disturbed area)
2.0 acre-ft
2 cfs (undisturbed area)
0.1 acre-ft

Max flow of 26 cfs flows out of cell

Runoff from berm

Max flow = 9 cfs off cell berm
0.5 acre ft.

3 MILE LANDFILL - RUNOFF FROM DISTURBED WASTE CELL- 25 YR, 24 HR
STORM HYDROGRAPH RAIN = 2.500 DURATION = 24.0 RUNOFF = .889
STORM DISTRIBUTION IS SCS 24-HR
CURVE NUMBER METHOD CN =80.0

TIME (HOURS)	RAINFALL (INCHES)	NET RAIN (INCHES)	DISCHARGE (CFS)
.000	.0000	.0000	.00
.100	.0030	.0000	.00
.200	.0030	.0000	.00
10.500	.0115	.0000	.00
10.600	.0155	.0002	.01
10.700	.0155	.0004	.03
10.800	.0155	.0006	.06
10.900	.0155	.0008	.10
11.000	.0155	.0009	.14
11.100	.0240	.0018	.17
11.200	.0240	.0022	.29
11.300	.0240	.0026	.39
11.400	.0240	.0030	.47
11.500	.0240	.0034	.55
11.600	.1040	.0186	.63
11.700	.1040	.0247	2.65
11.800	.1900	.0588	4.21
11.900	.2760	.1117	9.17
12.000	.2760	.1365	17.91
12.100	.0360	.0193	24.23
12.200	.0360	.0197	10.89
12.300	.0360	.0200	5.51
12.400	.0360	.0203	4.19
12.500	.0360	.0206	3.94
12.600	.0185	.0107	4.00
12.700	.0185	.0108	2.73
12.800	.0185	.0108	2.25
12.900	.0185	.0109	2.14
13.000	.0185	.0110	2.13
13.100	.0135	.0081	2.14
13.200	.0135	.0081	1.77
13.300	.0135	.0081	1.62
13.400	.0135	.0082	1.60
13.500	.0135	.0082	1.60
13.600	.0105	.0064	1.60
13.700	.0105	.0064	1.37
13.800	.0105	.0064	1.28
13.900	.0105	.0065	1.26
14.000	.0105	.0065	1.26
14.100	.0075	.0046	1.27
14.200	.0075	.0047	1.03
14.300	.0075	.0047	.94
14.400	.0075	.0047	.92
14.500	.0075	.0047	.91
14.600	.0075	.0047	.92
14.700	.0075	.0047	.92
14.800	.0075	.0047	.92
14.900	.0075	.0047	.92
15.000	.0075	.0047	.92

15.100	.0075	.0048	.93
15.200	.0075	.0048	.93
15.300	.0075	.0048	.93
15.400	.0075	.0048	.93
15.500	.0075	.0048	.93
15.600	.0075	.0048	.94
15.700	.0075	.0048	.94
15.800	.0075	.0048	.94
15.900	.0075	.0048	.94
16.000	.0075	.0048	.94
16.100	.0045	.0029	.95
16.200	.0045	.0029	.69
16.300	.0045	.0029	.60
16.400	.0045	.0029	.58
16.500	.0045	.0029	.57
16.600	.0045	.0029	.57
16.700	.0045	.0029	.57
16.800	.0045	.0029	.57
16.900	.0045	.0029	.57
17.000	.0045	.0029	.57
17.100	.0045	.0029	.57
17.200	.0045	.0029	.58
17.300	.0045	.0029	.58
17.400	.0045	.0030	.58
17.500	.0045	.0030	.58
17.600	.0045	.0030	.58
17.700	.0045	.0030	.58
17.800	.0045	.0030	.58
17.900	.0045	.0030	.58
18.000	.0045	.0030	.58
18.100	.0045	.0030	.58
18.200	.0045	.0030	.58
18.300	.0045	.0030	.58
18.400	.0045	.0030	.58
18.500	.0045	.0030	.58
18.600	.0045	.0030	.58
18.700	.0045	.0030	.58
18.800	.0045	.0030	.59
18.900	.0045	.0030	.59
19.000	.0045	.0030	.59
19.100	.0045	.0030	.59
19.200	.0045	.0030	.59
19.300	.0045	.0030	.59
19.400	.0045	.0030	.59
19.500	.0045	.0030	.59
19.600	.0045	.0030	.59
19.700	.0045	.0030	.59
19.800	.0045	.0030	.59
19.900	.0045	.0030	.59
20.000	.0045	.0030	.59
20.100	.0030	.0020	.59
20.200	.0030	.0020	.46
20.300	.0030	.0020	.41
20.400	.0030	.0020	.40
20.500	.0030	.0020	.40
20.600	.0030	.0020	.40
20.700	.0030	.0020	.40
20.800	.0030	.0020	.40
20.900	.0030	.0020	.40
21.000	.0030	.0020	.40
21.100	.0030	.0020	.40

21.200	.0030	.0020	.40
21.300	.0030	.0020	.40
21.400	.0030	.0020	.40
21.500	.0030	.0020	.40
21.600	.0030	.0020	.40
21.700	.0030	.0020	.40
21.800	.0030	.0020	.40
21.900	.0030	.0020	.40
22.000	.0030	.0020	.40
22.100	.0030	.0020	.40
22.200	.0030	.0021	.40
22.300	.0030	.0021	.40
22.400	.0030	.0021	.40
22.500	.0030	.0021	.40
22.600	.0030	.0021	.40
22.700	.0030	.0021	.40
22.800	.0030	.0021	.40
22.900	.0030	.0021	.40
23.000	.0030	.0021	.40
23.100	.0030	.0021	.40
23.200	.0030	.0021	.40
23.300	.0030	.0021	.40
23.400	.0030	.0021	.40
23.500	.0030	.0021	.40
23.600	.0030	.0021	.40
23.700	.0030	.0021	.40
23.800	.0030	.0021	.41
23.900	.0030	.0021	.41
24.000	.0030	.0021	.41
24.100	.0000	.0000	.41
24.200	.0000	.0000	.13
24.300	.0000	.0000	.03
24.400	.0000	.0000	.01
24.500	.0000	.0000	.00
TOTALS	2.500	.8889	173.98

STORM HYDROGRAPH VOLUME = 1.44 ACRE-FEET
MAXIMUN STORM DISCHARGE = 24.23 CFS

3 MILE LANDFILL - RUNOFF - 25 YEAR, 24 HOUR EVENT
STORM HYDROGRAPH RAIN = 2.500 DURATION = 24.0 RUNOFF = .356
STORM DISTRIBUTION IS SCS 24-HR
CURVE NUMBER METHOD CN =67.0

TIME (HOURS)	RAINFALL (INCHES)	NET RAIN (INCHES)	DISCHARGE (CFS)
.000	.0000	.0000	.00
.100	.0030	.0000	.00
.200	.0030	.0000	.00
.300	.0030	.0000	.00
.400	.0030	.0000	.00
11.700	.1040	.0000	.00
11.800	.1900	.0029	.00
11.900	.2760	.0267	.08
12.000	.2760	.0512	.73
12.100	.0360	.0083	1.61
12.200	.0360	.0087	.80
12.300	.0360	.0090	.45
12.400	.0360	.0093	.37
12.500	.0360	.0097	.36
12.600	.0185	.0051	.37
12.700	.0185	.0052	.26
12.800	.0185	.0053	.22
12.900	.0185	.0054	.21
13.000	.0185	.0054	.21
24.200	.0000	.0000	.02
24.300	.0000	.0000	.00
24.400	.0000	.0000	.00
24.500	.0000	.0000	.00
TOTALS	2.500	.3563	13.95

STORM HYDROGRAPH VOLUME = .12 ACRE-FEET
MAXIMUN STORM DISCHARGE = 1.61 CFS

3 MILE LANDFILL - RUNOFF - 25 YEAR, 24 HOUR EVENT
STORM HYDROGRAPH RAIN = 2.500 DURATION = 24.0 RUNOFF = 1.243
STORM DISTRIBUTION IS SCS 24-HR
CURVE NUMBER METHOD CN =86.0

TIME (HOURS)	RAINFALL (INCHES)	NET RAIN (INCHES)	DISCHARGE (CFS)
.000	.0000	.0000	.00
.100	.0030	.0000	.00
.200	.0030	.0000	.00
.300	.0030	.0000	.00
.400	.0030	.0000	.00
.500	.0030	.0000	.00
8.700	.0068	.0001	.00
8.800	.0067	.0002	.01
8.900	.0068	.0003	.01
9.000	.0068	.0003	.01
9.100	.0080	.0004	.01
9.200	.0080	.0005	.02
9.300	.0080	.0006	.02
9.400	.0080	.0006	.03
9.500	.0080	.0007	.03
9.600	.0090	.0009	.04
9.700	.0090	.0010	.04
9.800	.0090	.0011	.05
9.900	.0090	.0011	.05
10.000	.0090	.0012	.06
10.100	.0115	.0017	.06
10.200	.0115	.0018	.08
10.300	.0115	.0019	.09
10.400	.0115	.0020	.10
10.500	.0115	.0022	.10
10.600	.0155	.0031	.11
10.700	.0155	.0033	.15
10.800	.0155	.0035	.17
10.900	.0155	.0037	.18
11.000	.0155	.0039	.19
11.100	.0240	.0064	.20
11.200	.0240	.0069	.29
11.300	.0240	.0073	.34
11.400	.0240	.0077	.37
11.500	.0240	.0081	.39
11.600	.1040	.0391	.41
11.700	.1040	.0452	1.50
11.800	.1900	.0957	2.13
11.900	.2760	.1628	4.08
12.000	.2760	.1839	7.13
12.100	.0360	.0252	8.93
12.200	.0360	.0255	3.93
12.300	.0360	.0257	1.94
12.400	.0360	.0260	1.45

12.500	.0360	.0262	1.35	
12.600	.0185	.0136	1.36	
12.700	.0185	.0136	.93	14,000 ft^3
12.800	.0185	.0137	.76	
12.900	.0185	.0137	.72	
24.100	.0000	.0000	.13	
24.200	.0000	.0000	.04	
24.300	.0000	.0000	.01	
24.400	.0000	.0000	.00	
24.500	.0000	.0000	.00	
TOTALS	2.500	1.2435	64.90	

STORM HYDROGRAPH VOLUME = .54 ACRE-FEET
MAXIMUN STORM DISCHARGE = 8.93 CFS

Purpose: Calculate if detention pond and pond outlet will detain/pass 25-yr, 24-hr storm.

Given: Runoff = 27 cfs (intermittent stream) 3.6 acre-ft (runon → 0.3 acre-ft)
26 cfs (waste cell area) 1.56 ~~2.1~~ acre-ft
9 cfs (cell berm) 0.5
62 cfs + (8/2 cfs runon) = $\boxed{66 \text{ cfs}}$ 6.2 acre-ft + 0.3 = $\boxed{6.5}$

Pond outlet is 24" CMP → Max flow = 19.6 cfs (n=0.015, S=1%)

Calculate Pond Volume

Avg. depth = 8'
Length = 350'
Width = 40'

12.8 hr → Stream 50,344 ft³ | Runon ↓ 5,000 ft³ | Waste Cell 34,000 ft² | Berm 14,000 ft³

Total =

$\forall$ = 2.6 acre-ft

Calc. if: 1) Peak flow occurs well before the detention pond is full, ∴
2) Existing outlet will handle attenuated flow

At 12.80 hours into storm:

Total volume runoff ≅ 103,030 ft³ or 2.4 acre-ft
Flow at this time ≅ 14 cfs (which is less than 19.6 cfs)

∴ Detention pond will attenuate runoff so that existing 24" CMP outlet will handle 25-yr, 24-hr storm runoff.

Calculate Water Velocity (Intermittent Stream)

Given: Stream has b = 1', m = 2, n = 0.035, Q = 66 cfs

Slope	Depth	Velocity
2%	2.1'	6.2 ft/s

rip rap req'd 2% or greater

Purpose: Dimension waste cell

Assume: Waste thickness = 6' (cell only)

Waste Disposal

From "Summit County Solid Waste Management Plan", Bingham 1993

1992 → 20,088 TPY (Municipal + Non-Resident + Commercial)
2000 → 26,764 TPY

At 25,000 ton/yr and open 5 days/week (260 days)

$(25{,}000 \text{ ton/yr})(2000 \text{ lb/ton})(\text{yr}/260 \text{ days}) = 96 \text{ tons/day}$

* Design for 100 tons/day

Waste Cell Volume

Want cell to last at least 2 weeks

Volume required = (100 tons/day)(10 days) = 1000 tons

$(1000 \text{ tons})(2000 \text{ lb/ton})(\text{yd}^3/800 \text{ lb}) = \underline{2500 \text{ yd}^3}$

$\text{Area} = (2500 \text{ yd}^3)(27 \text{ ft}^3/\text{yd}^3)/(6 \text{ ft}) = 11{,}250 \text{ ft}^2$

*If square → 110' x 110' (12,100 ft²) perimeter = 3(110) = 330 ft

*If rectangular → one of the long sides will be the embankment

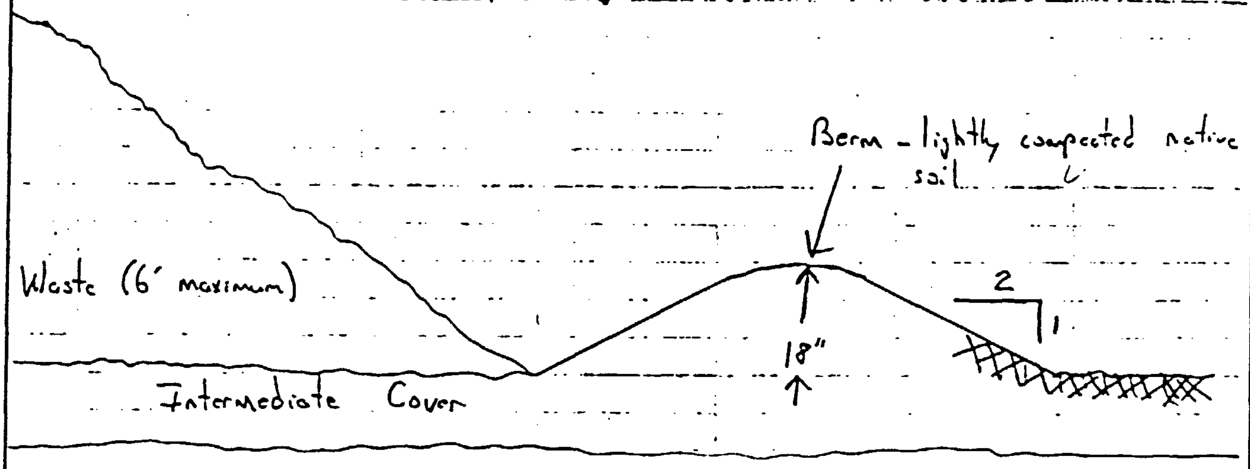
Use 150' x 75' cell perimeter = 150 + 2(75) = 300 ft

Size Berm

Given: Area = 11,250 ft^2
Precip. = 2.5"
Total rain volume is detained

Rain volume = 2,344 ft^2

Use soil berm 18" high



Volume of berm = $(18")(72")(330')/(ft^2/144 in^2)$ = 3000 ft^3 or 110 yd^3

If 12" → V = 12 (48")(330')/144 = 1320 ft^3 or $\underline{\underline{50\ yd^3}}$

12" Should be adequate → use 12"

EROSION POTENTIAL

EROSION POTENTIAL

In order to evaluate the long term performance of the landfill cover in terms of durability and integrity, the potential for erosion from the cap was calculated for both water and wind erosion. The reference used for these calculations is "Erosion Control During Highway Construction - Manual on Principals and Practices", National Cooperative Highway Research Program Report No. 221, Transportation Research Board.

WATER EROSION POTENTIAL

The potential soil loss from water erosion was evaluated using the universal soil loss equation. The equation is:

$$A = R \bullet K \bullet LS \bullet VM$$

where: A is the computed amount of soil loss per unit area for the time interval represented by factor R, generally expressed as tons per acre per year.

R — Rainfall factor -- obtained from a Mean Annual Iso - Erodent (R) Value map of the western United States. A value of 21 was used for this site. The value of R is then increase by a factor EI/R, which from Figure 2-1 for a period of 30 years is 2.1. Therefore, the value of R used in the equation is 44.1.

K — Soil erodability factor in tons per acre per year per unit of R. A value of 0.4 was determined based on site specific gradation data.

LS — Topographic factor (length and steepness of slope - dimensionless) -- calculated using the slope and slope length. The value calculated for the site is 1.7.

VM — Erosion control factor (vegetative and mechanical measures - dimensionless) -- based on graphs and dependent upon vegetative cover amount and type. Vegetative cover is expected to be a minimum 50 percent, with a 30 to 35 % canopy of tall weeds. The resulting value of VM is 0.05.

The calculated potential soil loss from the cell cover is 1.5 tons/acre/year, which is equivalent to a loss of approximately 0.0006 feet of soil per year.

CHAPTER 2

SOIL EROSION CAUSED BY WATER

INTRODUCTION

The universal soil loss equation (USLE) was developed by Wischmeier and associates (1, 31, 35, 41, 42, 49, 52, 53) for agricultural lands east of the Rocky Mountains. A modified equation, based on the USLE is used in this MANUAL for predicting soil loss due to water erosion on highway construction sites, and for determining the effectiveness of various erosion control measures. Each of the parameters in the equation affects the amount of erosion that will occur on any given site, and its value and use must be understood by each decision-maker to enable him to effectively control erosion. The modified universal soil loss equation used in this MANUAL is:

$$A = R \cdot K \cdot LS \cdot VM \quad \ldots\ldots\ldots \quad (2\text{-}1)$$

in which

A	=	computed amount of soil loss per unit area for the time interval represented by factor R, generally expressed as tons per acre per year
R	=	rainfall factor
K	=	soil erodibility factor in tons per acre per year per unit of R
LS	=	topographic factor (length and steepness of slope) (dimensionless)
VM	=	erosion control factor (vegetative and mechanical measures) (dimensionless)

Additional information is presented in the appendices for utilizing these various factors in the determination of erosion amounts. Appendix B contains a nomograph for solving the water soil loss equation together with several examples of its use for solving practical field problems. Appendix C provides detailed examples of water erosion calculations and gives computational procedures for determining the topographic factor LS for single and multiple slopes and the erosion control factor VM. Appendix E explains the procedure for determining R from rainfall records, and Appendix F presents the results of studies to extend the use of the universal soil loss equation to steep slopes.

RAINFALL FACTOR R

The rainfall factor is the number of erosion index units in a normal year's rain. The erosion index is a measure of the erosive force of specific rainfall, and is defined for a single storm as:

$$R = \frac{EI}{100} \quad \ldots\ldots\ldots \quad (2\text{-}2)$$

in which

E	=	total kinetic energy of a given storm
I	=	the maximum 30-min. rainfall intensity.

The rainfall factor, R, is computed from rainfall records of individual storms and summed over a given time interval to obtain the cumulative R value to be used in the soil-loss equation. R is derived from probability statistics and thus should not be considered as a precise estimator of soil loss. Its value lies in its use as a predictive tool and risk evaluator. Construction activities in areas with high values of "R" will require greater attention to erosion control practices than similar construction in areas of low "R" values.

The R factor maps prepared by Wischmeier and Smith (52) cover most areas east of 104° west longitude but nothing in the western United States, Alaska, or the Islands. The present project extended these maps to include the other areas mentioned. In 1978 Wischmeier and Smith extended the R factor maps westward to the Pacific (56).

A publication of the Soil Conservation Service, SCS (44), shows a curve for the western part of the United States for the relation of 2-year, 6-hour rainfall depth to EI values with a correlation (r^2 = coefficient of determination) of approximately 90 percent. This regression in combination with the 2-year, 6-hour rainfall maps given in Weather Bureau Technical Paper No. 40 and NOAA Atlas No. 2 was used to construct the national R factor maps of Figures 5-1 and 5-2 in the map pocket at the back of the MANUAL.

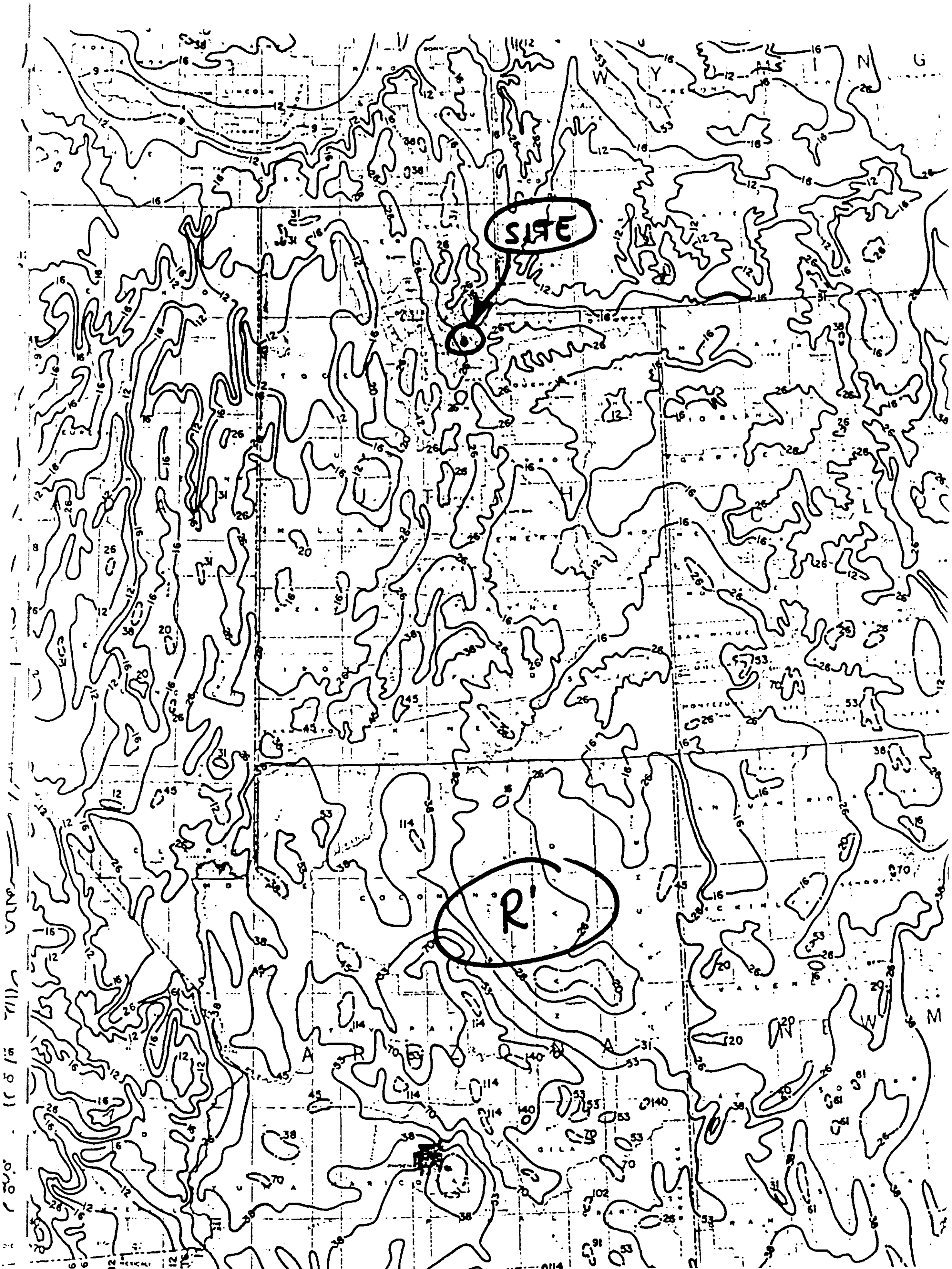
Similar maps of Alaska, Hawaii, and Puerto Rico were derived from information given in Weather Bureau Technical Papers 42, 43, and 47. These maps are shown in Figures 5-2 and 5-3.

Wischmeier and Smith (52) state that the rainfall factor R does not completely describe locational differences caused by rainfall patterns and they proposed the seasonal distribution parameter, which is a sigmoidal curve, as a percentage of the annual R value. They developed a zonal map of these curves for part of the United States. Using available rainfall data, the present project has extended this map and curves to include the rest of the country. The resultant extensions are given in Figures 5-4, 5-5, and 5-6, located in the map pocket.

The data for recurrence interval variations in EI values given by Wischmeier and Smith (52) were utilized to develop the recurrence diagram given in Figure 2-1 which shows the relationship between the annual EI value which has a return period of 2 years and that for other return periods. A strong correlation exists between R (the mean annual value) and EI (50-year recurrence) with a coefficient of determination, r^2, equal to 0.96 with similar reduction for other recurrences. It is, therefore, believed that any recurrence desired may be derived with adequate precision through the use of this figure.

R values for periods of less than one year can be determined from the appropriate distribution curves, Figures 5-4, 5-5, and 5-6.

To illustrate the use of the iso-erodent (R-factor) maps consider the following example of a construction site in the northwestern corner of Missouri. From the iso-erodent map which includes Missouri (Figure 5-1), it is determined that R = 165.



SITE
R'

which will be discussed later. For a first approximation of the erodibility of soil in a given area of the United States, refer to the soil erodibility maps, Figures 5-8 and 5-9, in the map pocket. For a specific construction site a better procedure is to obtain representative samples of the soil in question and determine their percentage of silt plus very fine sand (0.05 mm to 0.10 mm) and the percentage of sand (0.10 mm to 2.0 mm). The percentage organic matter should also be determined. With these values, enter Wischmeier's 1971 soil erodibility nomograph, Figure 2-2, and determine the appropriate value of K to be used in the equation. If, for example, the soil from a construction site in northwestern Missouri contains 65 percent silt plus very fine sand, has 5 percent particles in the sand category, and contains 2.8 percent organic matter, the K value first approximation will be about 0.28 which corresponds also with the erodibility map in Figure 5-8. If in addition the soil is determined to have a structural value of 2 and a permeability of 4, the K value is 0.31 (structure and permeability value ranges are defined in Figure 2-2).

NOTE: VALUES DETERMINED FROM THE SOIL ERODIBILITY MAPS, FIGURES 5-8 AND 5-9, SHOULD BE USED ONLY WHEN SITE-SPECIFIC SOIL ANALYSES ARE NOT AVAILABLE. These maps were prepared from the latest information available from the Soil Conservation Service and from individual states, but at best are only rough approximations of soil erodibility values of specific sites.

In those states where more detailed information was not available, values from the national soil survey were used. This procedure resulted in some instances in soil classifications following state boundaries, which, of course, is not according to fact.

TOPOGRAPHIC FACTOR LS
(see Appendix C for additional details)

The only manageable parts of the soil loss equation are the topographic factor LS and the erosion control factor VM. The rainfall factor R and the soil erodibility factor K have both been fixed by nature and cannot be altered by man's activities. The steepness and length of many of the slopes in highway construction, however, are determined by man after he considers the physical setting of the construction site and the requirement of the transportation system. It is obvious that flat slopes and short lengths will have less erosion than steep slopes and long lengths, but the amount of erosion expected for various combinations of length and steepness is not so obvious. The LS factor is therefore a numerical representation of the length-steepness combination to be used with the rainfall factor R and the soil erodibility factor K to estimate the erosion rate potential for a particular construction slope. Since the slope and length are determined by the highway designer, a knowledge of the LS factor will aid him in choosing proper combinations of slopes and lengths, and determining when to use berms, cross ditches, terraces or other control practices which effectively reduce the LS factor.

For determining the LS factor in the soil loss equation, the following relationship is given by Foster and Wischmeier (31) and by Wischmeier and Smith (48, 56).

$$LS = \left(\frac{l}{72.6}\right)^m \left(\frac{65.41\, s^2}{s^2 + 10,000} + \frac{4.56\, s}{\sqrt{s^2 + 10,000}} + 0.065\right) \qquad (2\text{-}3)$$

in which

- LS = topographic factor
- l = slope length in feet
- s = slope steepness in percent
- m = exponent dependent upon slope steepness (0.2 for slopes < 1 percent, 0.3 for slopes 1 percent to 3 percent, 0.4 for slopes 3.5 to 4.5 percent, and 0.5 for slopes > 5 percent)

The graph in Figure 2-3 has been developed for solving Equation 2-3 and is used in the following manner. The value of the slope gradient is located on the bottom scale of the graph. This value is followed vertically to the appropriate slope length curve, and the corresponding LS value is read on the left hand scale of the graph. (See also Table C-1.)

Referring to Figure 2-3 it is determined that if the site calls for a fill slope 100 feet long at a steepness of 67 percent (1-1/2:1), the LS factor value from the graph is about 27. Reducing the slope to 50 percent increases the length to 124 feet (increasing the exposed area by 24 percent), and the new LS factor value becomes 20. The erosion rate potential has thus been reduced to 74 percent of the original and the erosion amount (rate x area) to 95 percent (assuming no erosion prior to exposure). Further reducing the slope to 3:1 (33 percent), the LS factor value becomes 13 or 47 percent of the original. A 6:1 slope would reduce the LS value to about 6 or nearly 21 percent of the first design, but the slope length has now more than tripled to 339 feet, and the total amount of erosion has reduced to about 71.1 percent of the original. Cutting the slope length in half cuts the erosion by approximately one-third or to 70 percent of the original amount.

EROSION CONTROL FACTOR VM
(see Appendix C for additional details)

The erosion control factor is applied in the equation as a single unit. It accounts for the effects of all erosion control measures that may be implemented on any particular construction site, including vegetation, mechanical manipulation of the soil surface, chemical treatments, etc. It does not include structures such as berms and ditches. These are part of the topographic factor, LS. For any site the soil loss equation may be solved with and without erosion control measures installed and the difference in the "A" values determined is an indication of the effectiveness of that particular control system.

From research results reported in the literature, it was noted that mulches had apparent VM factor values commonly around 0.01 until R·K·LS factor values exceeded a certain critical level at which point the mulch partially failed. Thus for each set of R·K·LS values it is assumed that a certain quantity of mulch is required to maintain the VM factor value at a level near 1 percent. Figures 2-4, 2-5, 2-6, and 2-7 were developed for this MANUAL using data gathered from both published and unpublished sources and show this relationship for straw or hay mulch not tacked (some states apply mulch in this

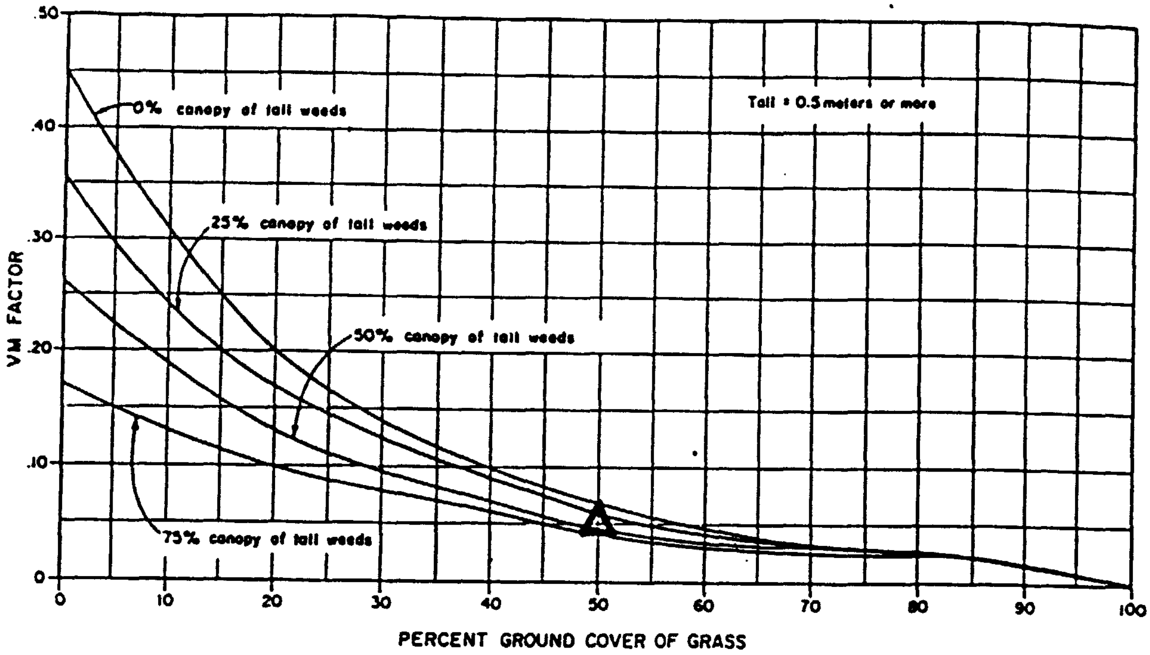


Figure 2-8. Relationship between grass density and VM factor.

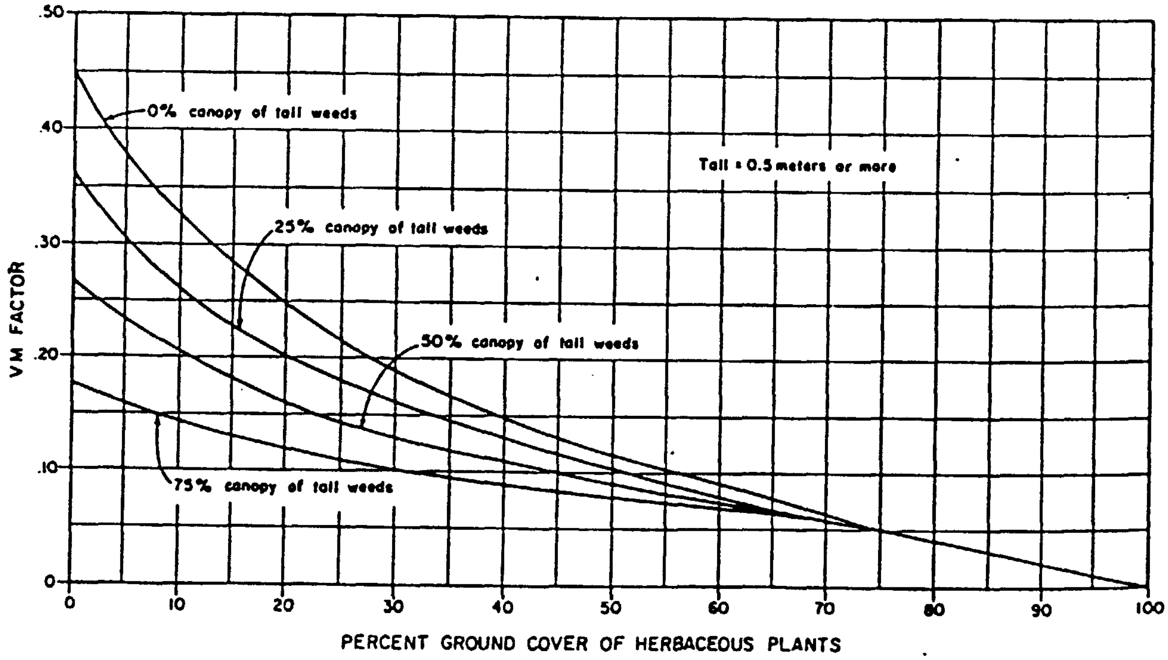


Figure 2-9. Relationship between forb density and VM factor.

WIND EROSION POTENTIAL

The potential soil loss due to wind erosion was evaluated using the following wind erosion equation (Primes are added to the factors to avoid confusion with the waster soil loss equation):

$$E' = I' \bullet C' \bullet K' \bullet V' \bullet L'$$

where: E' is the computed soil loss by wind in tons per acre per year. It must be noted that the value of E' is derived by using the attached nomograph (figure 3.3) and not by simply multiplying the other values.

I'	Soil wind erodability factor -- dependent upon the percent of material not passing the #20 sieve, which is estimated to be over 90% for the topsoil material at the site. The value conservatively estimated from the tables is 41.7.
C'	local wind erosion climatic factor -- obtained from wind erosion C' factor isomaps for the United States. The value obtained is 0.62.
K'	soil surface roughness factor -- a measure of the natural or artificial roughness of the soil surface in the form of ridges or small undulations. Assuming 2 to 3-inch undulations results in a K' value of 0.5.
V'	vegetative factor -- represents the equivalent pounds of vegetative matter as a roughness element. A conservative estimate of 500 pounds of vegetative matter per acre yields a V' value of 3000 pounds per acre.
L'	length of the unshielded distance parallel to wind in the direction of the wind fetch -- a length of 1000 feet, the longest slope, was used.

Using these values in the equation results in a wind soil loss of 0.68 tons/acre/yr. For an average soil density of 110 pounds per cubic foot, this rate results in a soil loss of approximately 0.00028 feet per year.

Table 3-1. Soil wind erodibility index I.

Percent of Dry Soil Not Passing a 20 Mesh Screen	0	1%	2%	3%	4%	5%	6%	7%	8%	9%
(Units)	Non-crusted Soil Surface (tons/acre)									
0	-	310	250	220	195	180	170	160	150	140
10	134	131	128	125	121	117	113	109	106	102
20	98	95	92	90	88	86	83	81	79	76
30	74	72	71	69	67	65	63	62	60	58
40	56	54	52	51	50	48	47	45	43	41
50	38	36	33	31	29	27	25	24	23	22
60	21	20	19	18	17	16	16	15	14	13
70	12	11	10	8	7	6	4	3	3	2
80	2	-	-	-	-	-	-	-	-	-
	Fully Crusted Soil Surface (tons/acre)									
0	-	51.7	41.7	36.7	32.5	30.0	28.3	26.7	25.0	23.3
10	22.3	21.8	21.3	20.8	20.2	19.5	18.8	18.2	17.7	17.0
20	16.3	15.8	15.3	15.0	14.7	14.3	13.8	13.5	13.2	12.7
30	12.3	12.0	11.8	11.5	11.2	10.8	10.5	10.3	10.0	9.7
40	9.3	9.0	8.7	8.5	8.3	8.0	7.8	7.5	7.2	6.8
50	6.3	6.0	5.5	5.2	4.8	4.5	4.2	4.0	3.8	3.7
60	3.5	3.3	3.2	3.0	2.8	2.7	2.7	2.5	2.3	2.2
70	2.0	1.8	1.7	1.3	1.2	1.0	0.7	0.5	0.5	0.3
80	0.3	-	-	-	-	-	-	-	-	-

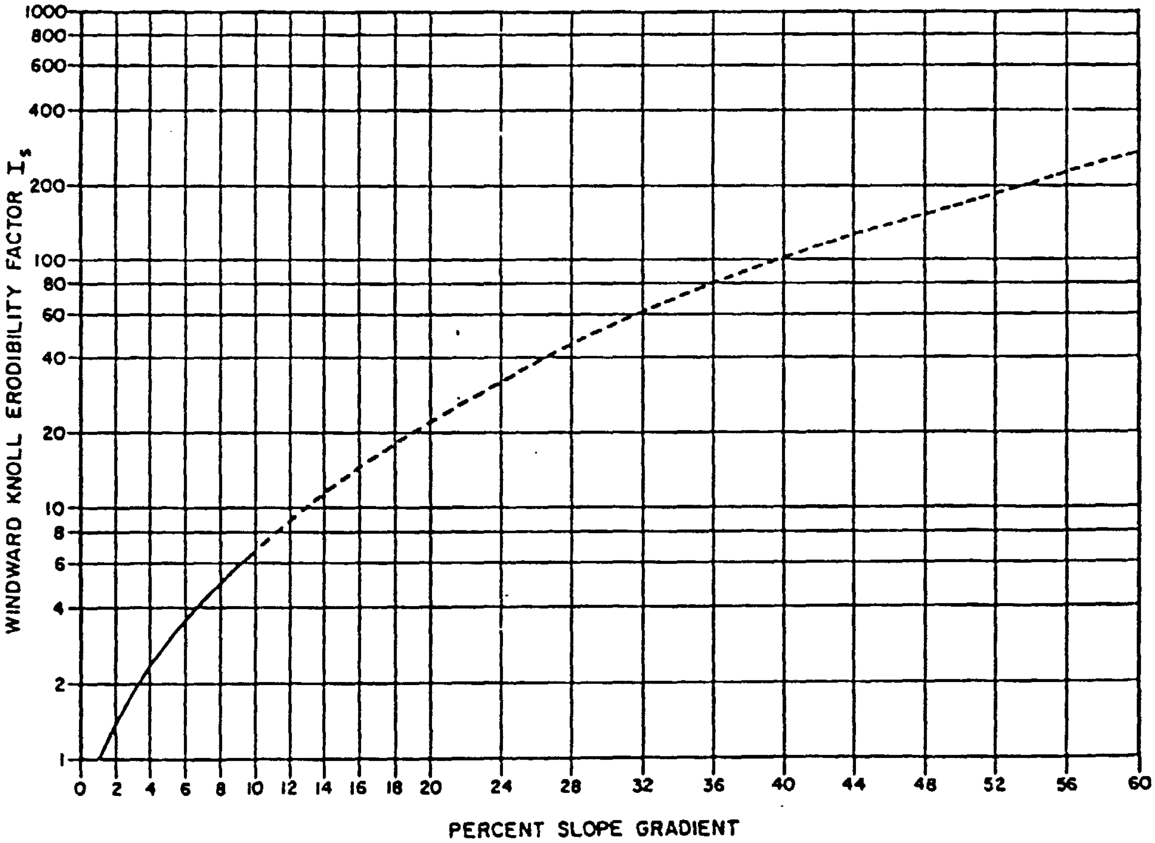


Figure 3-0. Slope steepness vs. I_s.